ENLARGED EDITION

How to WIRE your Model Railroad

by

Linn H. Westcott

Over 200 diagrams, charts and photos. Wiring made simple and clear for everyone.

How To Wire Your Model Railroad

By Linn H. Westcott

The simple how-to-do-it diagrams and nontechnical language of this book have made model railroading more fun for over a hundred thousand scale railroad enthusiasts.

Even if you don't know a watt from an ampere, you'll find you can still wire a simple or a complex track plan with the help of this book. The author talks to you as though he were across the workbench or kitchen table, working with you in building and wiring your own railroad.

Linn Westcott has been model railroading since the early thirties and his name is closely associated with many basic developments in the hobby. The suggestions Linn makes to you are based on his conviction that the simplest way to get smooth, realistic, train operation on your pike is the best. No complicated equipment is required.

How to Wire Your Model Railroad

By Linn H. Westcott

Vice-President and Editorial Director
Kalmbach Publishing Co.

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Acknowledgment

It is customary to give credit where it is due when a new book is prepared. My problem is that it is impossible to single out the originator of many of the ideas grouped into this book. When a fellow gets a new idea, he shares it with his friends. This sets off a whole family of new ideas and the thing snowballs. Soon it becomes impossible to say just who started the trend and who contributed the most to it.

Perhaps you, Mr. Reader, are one of the idea-creators in model railroading — one of the fellows who has helped to make this the best of all hobbies. If so, thanks a lot for your help, and I wish it were possible to write your name right here along with a thousand others.

There is another kind of help that I can acknowledge more specifically. My job was one of sorting out a group of methods that would all work together and that would also lay a sound foundation for a growing control system. Bill McAllister of Cincinnati was very helpful in criticising parts of this work. Glenn Parker, Frank Grabowski, and Ann Mullen helped with typographic and production problems. Bill Wight, Dave Strassman, and Webster Christman patiently converted my rough pencil sketches into finished drawings.

L. H. W.

Contents

George Wannamaker adopted toy railroad apparatus to control his Santa Fe System at his home in Detroit. Railroad — a double track oval with yards.

Foreword

This is a book which has been written twice. It was originally conceived on the premise that the wiring of a model railroad could be explained without a short course in electrical engineering as chapter one. But the first version, after a year of work, satisfied neither author nor publisher. It was too advanced, assumed too much knowledge of electricity on the part of the model rail who would use it.

So this version, the second, was written from scratch. I think it is the first really practical manual on model railroad wiring. It is written for the railroader, not the electrician. Without going deeply into electrical theory, it answers the questions that we are so often asked here at MODEL RAILROADER magazine.

In many ways it is a revolutionary book. Two years of preparatory work and thousands of hours of drafting work are all put between an inexpensive binding so that the price can be kept at a low, popular level. The binding of most books costs more than the printing. We are betting that you are more interested in information and practical help than in an expensive cloth binding. Likewise, we have printed the entire book in two colors because the second color makes the diagrams more clear and useful.

Linn Westcott, the author, is a man who has made a lifetime career of model railroading. He studied city planning and architecture, but immediately after college he came to the MODEL RAILROADER magazine in its second year (1935) and has been here ever since. A great deal of his time here is devoted to model railroad research. He is vice-president and editorial director.

Both Linn and I hope that *How to Wire Your Model Railroad* helps you to have more fun with model railroading.

A. C. Kalmbach, Publisher

Realistic Control

WHAT is it that makes model railroading such a captivating hobby? Why has our hobby grown faster than others in recent years?

Well, there is the irresistible lure of the railroad and the intrigue of things in miniature, but other hobbies have comparable advantages. I think the feature that makes model railroading the most distinctive hobby is that it has the greatest diversity. You can be an all-around fellow or you can specialize. And what's more, there are so many different things you can specialize in with your model railroad. Mechanics, design, art, collecting, display, handicraft, carpentry — all are phases of our hobby you can take or leave, as you prefer.

And there is another whole group of appeals; you might call them the active side of model railroading. Unlike many other hobbies, in model railroading you are only partly finished when you put the last touches of paint on a model. Here our fun is just beginning. Your new car, locomotive, or bridge is another integral part of the working railroad you build in your own home. It is no longer just a mechanical model. It doesn't have to gather dust on the mantel. Now it is a pawn or a king in the game-like operation you can play with your pike.

The active side of model railroading is the secret of the hobby's big success. First you build a *model;* then you become a *railroader.*

But you are already sold on model railroading; why should I waste your time with a sales talk on our hobby?

Because I want to make this point clear: Model construction and railroading are two separate aspects of the hobby. Each is an end in itself, yet each augments the other. Between these two interlocked phases of model railroading is *control.* Control is the whole subject of making trains move and move realistically. The man who masters control has the key to really successful model railroading.

Fortunately, control wiring is the easiest part of model railroad building. You use simple tools, there are no close measurements, and the work usually goes quickly. Your whole wiring job may be done in much less time than it takes to get ready for it.

Most model railroad beginners are not as familiar with the ways of electricity as they are with those of the hammer and nail, and that is why control looks complicated and mysterious at first.

When you actually do the work, all the mystery will quickly disappear and soon you may even be giving the other fellow some help.

There are tempting short cuts in control work. Loose, tangled wires are easy to install, but they are likely to waste hours and hours of your time within the first few months. Spend an extra minute out of every ten to keep your work neat and troubles are much less likely to develop, ever.

If you build a good control system, you will have plenty of power ready to run your locomotive. When you pull the throttle, the engine will respond with slow but powerful motion. It will pull its load easily up grades and around tight curves. You should be able to run the train at scale speeds of 20, 40, or 80 miles per hour.

With a good control system you can put an end to the jerky starts and stops of toy railroading. A real train takes many minutes to reach full speed and a model should take at least several seconds.

In this book I shall show you how to build a control system for your railroad that will give you convenient and responsive control. I hope to include everything you need to know to get at least one train running smoothly and with a minimum of effort, time, and expense on your part.

When you are ready to run two or more trains, you will need more control equipment. This is so that each train can run at its own speed and in its own direction. The control equipment you add is in addition to the basic controls you build for the first train. I'll tell you a little about cab control and other ways to handle several trains in chapter 16 but the subject is so big that much material about cab control will have to wait for another book.

Operation

You can run your railroad in many different ways. Some fellows like to set the throttle and watch a sleek streamliner or a 30-car freight run around and around many times.

Some fellows prefer to be towermen. For them an interlocking plant at a junction is the most fun. As several trains run about the railroad on as many routes, the towerman sets the "levers" at his junction and waits for the cars to weave through.

Almost everyone likes to be an engineer. Controls built like those in a real locomotive work well here and the engineman keeps his eye on his train no matter where it goes. He brakes for the curves and builds up speed on the straightaway.

These are only a few of the jobs that a model railroad offers, and they all center about a good control system. In this book we'll get to a good start on control. The methods we will use are just about the easiest of any yet developed, but they will also be a sound foundation if you should care to add refinements later on.

Traffic direction

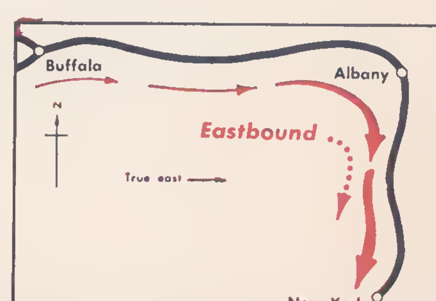
One idea, borrowed from the real railroads, will be so helpful that I want to introduce it right away. This is the concept of "traffic direction." If you can read a map, you are probably accustomed to thinking of things in terms of four directions: north, east, south, and west.

But the operating department of a railroad ignores true direction almost entirely and everything is converted into two directions as measured along the actual route of the track.

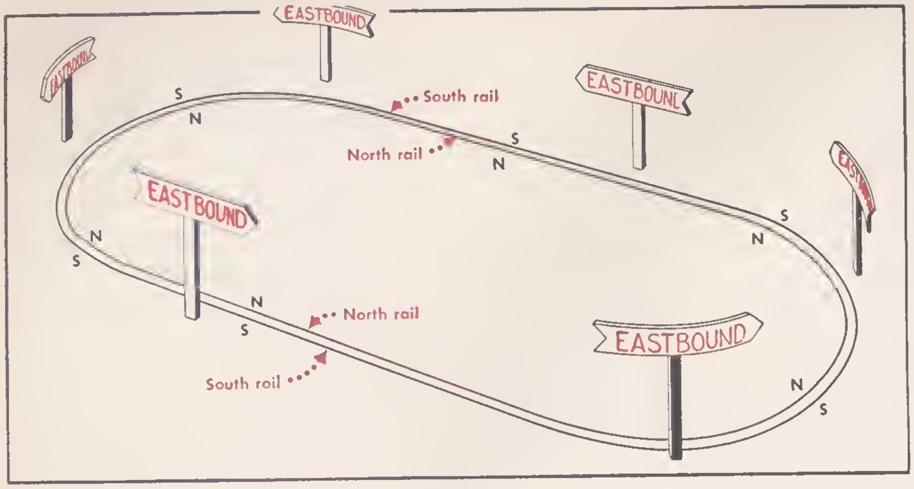
Over in England, for instance, the directions are called "up" and "down" depending on whether a train or track runs to or from London.

In our country most railroads use "eastbound" and "westbound" most often but some lines use "northbound" and "southbound" instead.

New York Central belongs to the group that uses the east-west nomenclature, and this line has a fine example to show what eastbound really means. The main line runs generally east from Chicago to Buffalo and Albany but here it makes an abrupt right turn and continues south by west to New York City. On this last



1-1 Eastbound is not necessarily true east.



1 - 2 Counterclockwise is eastbound on an oval track.

leg of the journey the trains sometimes turn entirely west but they are still called "eastbound," see Fig. 1-1.

All trains going toward New York are eastbound trains regardless of the twists in the track.

On your own railroad you can assign one terminal as "east" and all track leading toward this terminal is then eastbound.

At first you might not think this practical because so many model railroads are built in an oval or some other kind of continuous pattern. But here we have a convention you can use; just consider the generally counterclockwise direction as eastbound. Fig. 1-2 shows this.

This practice will help later on when you plan a schedule for running trains, but it is going to be very important for your wiring, too, because now we have a simple way to name the two rails of the track. If we call one rail *S* for south and the other *N* for north we'll always be able to distinguish one from the other and not get the wires mixed up as easily. Fig. 1-2 shows this also.

Notice that the *N* rail is always on the inside of the oval. In effect you have placed the north pole in the center of your railroad system.

A word to the wise

As a rooter for model railroading, you can do something to help others who are just getting started. If the average fellow picks up this book he's likely to say to himself:

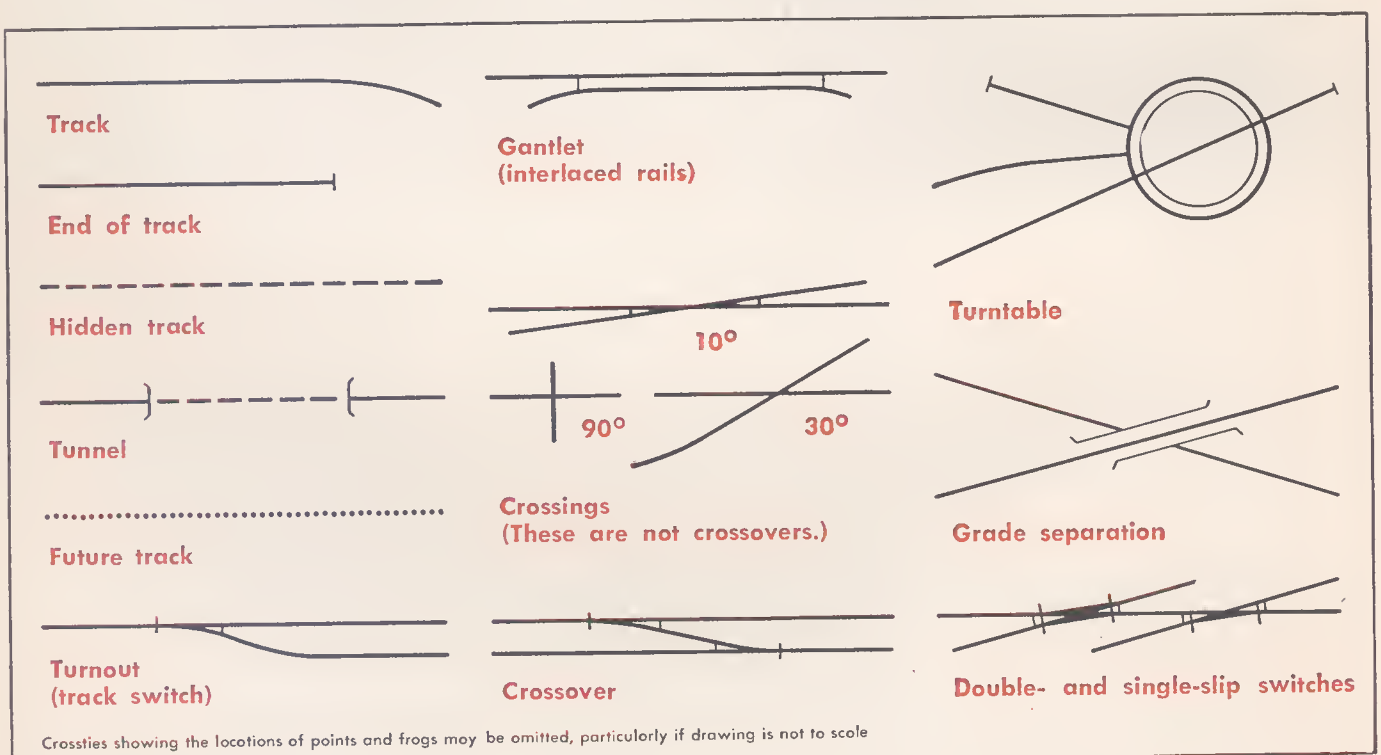
"Holy smoke! If I have to learn all the things in this book just to wire my railroad, I'm going to push my trains around by hand."

Here's what you tell your friend:

"Take it easy, brother. There are a lot of kinds of model railroader and each one wants to do some things in his own way.

"That wiring book has to give information to each of those fellows and so there is much more material there than you will ever use."

And I'll try to do my part by letting you and your friend know when you come to places you can skip over.



Use these symbols whenever you draw track plans for wiring purposes.

What You Need

When you are getting ready to wire your model railroad, it's a good idea to draw a plan of your track right away. You can draw two lines for a track—that is, one for each rail—but that's a lot of work. It is much easier to draw only one line to represent both rails, and this will be good enough for wiring planning.

Use the symbols on page 2 and be sure you get all the turnouts (track switches) in the right relationship to each other. Except for this, your drawing can be very crude. Of course, a large drawing will be easier to use than one on a letterhead size sheet.

We aren't going to add any wiring to your plan for a while, but it is still a good idea to keep this drawing nearby. Since I'm going to say some things in this book that are for the other fellow's railroad instead of yours, it will be best to keep your own track plan handy. This will make it easier for you to sort out the data you need.

Perhaps you want to build a small test track first and a bigger railroad later on. This is very sound planning on your part, because every model railroader does a better job each time he starts a new railroad. The wiring for a simple test oval or yard is as easy as pie, and you won't have to read even half of this book to do it.

When you build a bigger railroad with more turnouts the wiring is naturally going to be a bigger job, too.

Before leaving track planning, let me assure you that no matter how you design your track, you *can* wire it. There's no need to change a track plan to make the wiring easier. Your track plan should be arranged for good train operation, practical switching moves, and interesting railroading.

How many trains will you run?

A one-train test railroad requires about the same amount of wiring as a toy railroad around a Christmas tree. The job is mostly one of choosing the parts to fit your desires and budget.

When you are ready to run two or more trains, the wiring is still easy but there is more of it. Of course, you can run two trains on a test railroad, but they'll both go the same speed and in the same direction whenever they travel. Wiring for two or more trains should provide for independent control of each train, and we'll see how to do it later on. In the meantime, most of the things I will tell you about one-train wiring will be essential for you if you plan to run more trains later on.

The control circuit

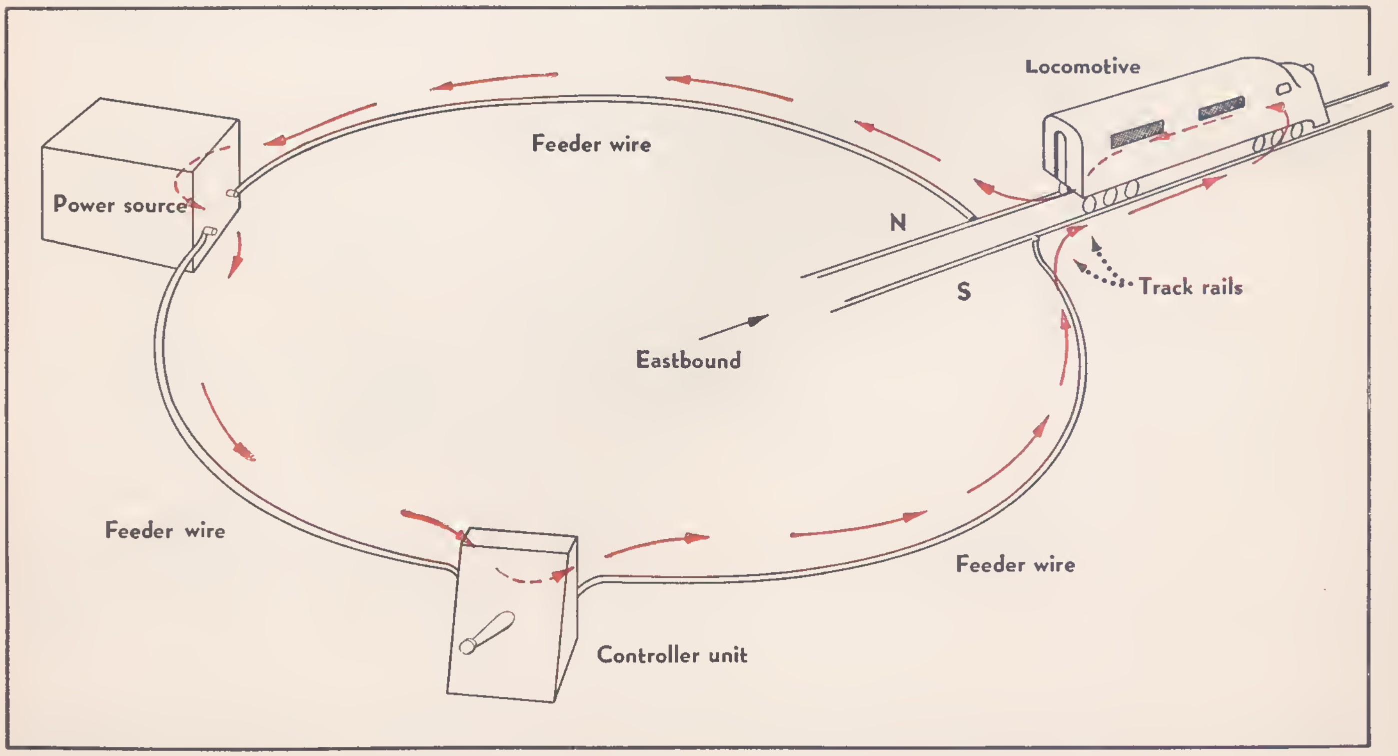
The large diagram below shows how electricity is harnessed to run a locomotive on your system.

Notice the cast of the scene. It includes five principals:

1. Power source
2. Controller unit
3. Feeder wires
4. Track rails
5. Locomotive

Notice something else that is very important. All of these components are connected in a sort of necklace of events around which the electric current can circulate. The electric power is pumped around this daisy-chain by the power source. A feeder wire guides it to the controller unit which is a sort of valve that regulates the flow. Another feeder continues the path to the track. Electricity can flow through metals but not through air, and that is why it stays in the feeder wire. The rail of the track is also metal, so the electricity can move along the rail as far as necessary to reach the locomotive.

At the locomotive the electric cur-



2-1 All train-control wiring is based upon this simple circuit. N and S indicate individual north and south rails.

rent leaves the rail and passes up through a wheel or special collector shoe to a short wire and finally reaches the motor, Fig. 2-2. Here it develops the power to pull a train.

But this is only half of our story. Electricity has to pass *through* a motor, not just to it. And if it must flow through, you'll need another path to return the current home again. This return path is the other rail of the track and then another feeder which reaches the other terminal connection on the power source, Fig. 2-1.

Now we have the underlying principle of electric power machines. You must have a complete "circuit" of wires, rails, or other conductors so the electric current can flow around and around passing through each component in turn.

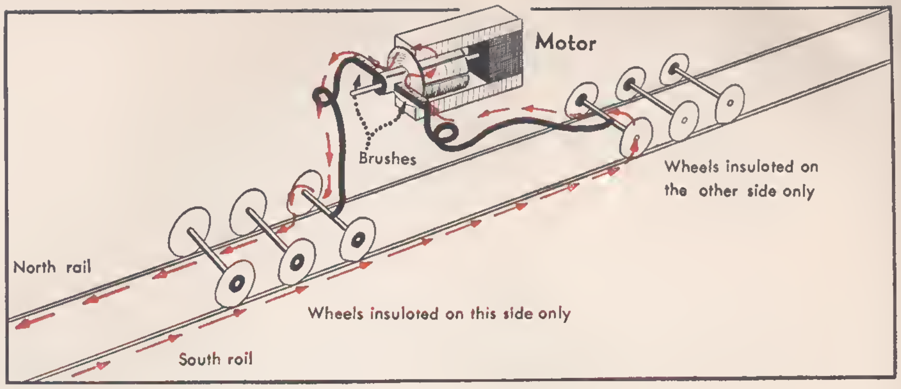
So let's remember this basic clue that helps not only in our planning but also in locating more than half the troubles that might develop later on:

Electricity can flow only if there is an unbroken path from the power source, through the other elements of the circuit, and back to the source by another route.

Locomotive wiring

You might wonder why the electricity flowed along the rail past the first wheels and on to the second in Fig. 2-2. This is because there is a small bushing of plastic near the hub or the rim of all the wheels on the near side of the near truck. This "insulation" prevents electricity from flowing up to the locomotive because there is no all-metal path here. The electricity can flow into the locomotive at the second truck because these wheels are not insulated.

This same insulation scheme is used to make the electricity flow out of the locomotive via the far side of the near truck.



2 - 2 Electricity passes from one rail through the motor to the other rail.

The connecting wires don't actually fasten to the axles of your wheels. Instead they go to the truck frames. Sometimes the metal frame of the locomotive replaces one of these connecting wires and when this happens we say the motor has "one brush grounded."

Series and parallel

All the components, including the wires and rails, of our daisy-chain were connected end to end in a series so this is called a "series" circuit. All circuits have at least two elements in series but sometimes a part of a circuit can be "parallel" to another part. Suppose you have another locomotive and you put it on the track as shown in Fig. 2-3.

Now electricity has two routes at the right side of the circuit. It has a choice of passing through either locomotive. Well, electricity is very democratic and it will always divide itself, part of it going each way, whenever there are two paths. Thus each locomotive will receive part of the power and the two are said to be in "parallel." This may be more clear if you study the schematic diagram of Fig. 2-4.*

Later on I'm going to tell you how to choose the components of your control circuit and how to use them, but first let's get a bit of background.

Electric current

You don't have to know much about electricity to wire your railroad, but I'm going to outline a few things that can make the work more interesting and also make it much easier to find the source of trouble if you ever have it. As you know, all materials are supposed to be made of ultra small particles called atoms, and each atom has much smaller particles called electrons that dance around it. When you make something warm, all you are really doing is making the electrons dance faster.

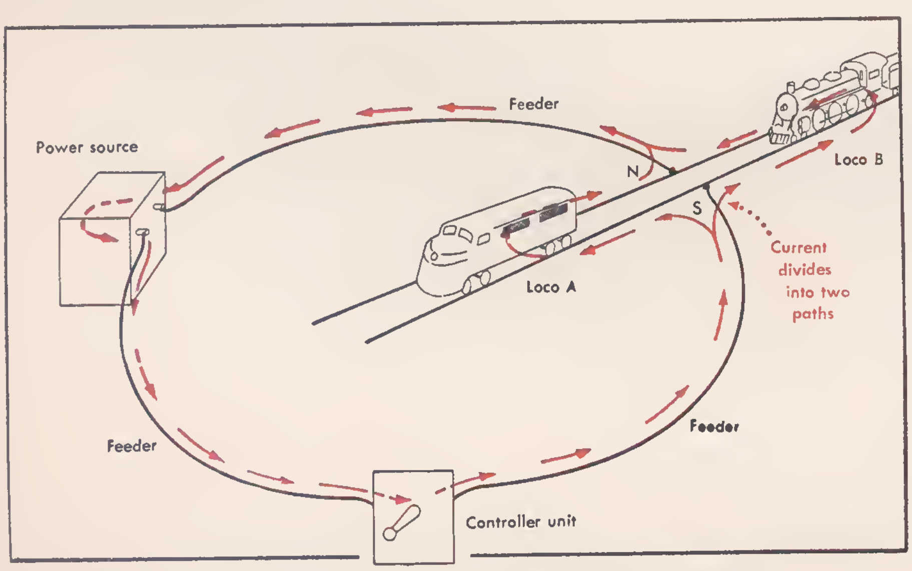
In metals the electrons may not always dance around the same atom. Instead they migrate from one host to another in haphazard fashion.

If you can make the dancers migrate a little more in one direction than any other, as they bounce and whirl, you have an electric current, Figs. 2-5, 2-6, and 2-7.

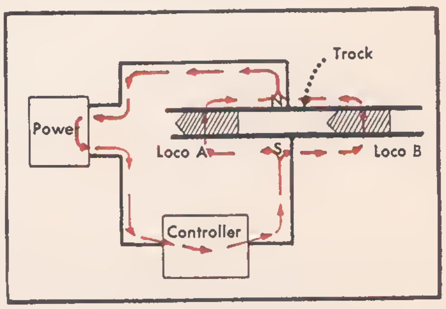
Now it is easy to see why you must have a complete circuit for electricity to move around. If electrons cannot move all the way around, they will pile up somewhere; the parade stops and no useful work can be done. Fig. 2-8 is an example of this.

You may have heard that electricity

*Schematics are a type of shorthand that is much easier to follow than a pictorial diagram when you want to show what is happening in an electric circuit. On the other hand, because they are made of unfamiliar shapes and do not look like the actual parts, schematics are not as good to show how to build and wire a control system.



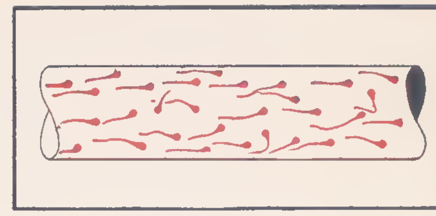
2 - 3 Since electricity divides and follows two paths these engines are in "parallel."



2 - 4 Schematic diagram of Fig. 2-3.

2 - 5

2 - 6



2 - 7

These diagrams represent a wire and the dots with tails represent electrons within the wire. Ordinarily the electrons dance about in hap-hazard fashion, 2-5. When a wire is heated the electrons dash more quickly, 2-6. If you can make the electrons move more in one direction than in any other you have produced an electric current, 2-7. The relation between current and heat is always a close one.

travels at the speed of light, but this isn't strictly true. The dancing electrons actually migrate rather slowly through a wire. The thing that moves fast is the push of one electron upon another.

This works like a row of dominoes touched at one end: each domino falls over and touches the next. In a second or so the wave of pressure may be several feet away, yet each domino has moved only an inch.

When you push an electron it moves slowly, too, but the wave of pressure is nearly instantaneous. That's why the motor in a locomotive starts to work the moment you pull the throttle.

When only a few more electrons move in one direction than in the other, as all of them dance, you have a weak electric current. If a great many electrons move onward, the current is heavy. Current is measured in units called "amperes" or just "amps" and usually abbreviated "a." Most HO gauge locomotive motors will run full speed with less than 1 a. of electric current flowing through their coils, but some big O gauge motors use 4 a. or more.

When a motor delivers less than full power, it is usually because its diet of amperes has been restricted.

In many ways an electric current behaves like water passing through a pipe. If the pipe is level and filled with water, the water still won't flow unless you have a pump or something else to push it.

In the same way, although a wire is filled with electrons, you need some kind of electrical pressure to make the electrons move in one direction.

Again, suppose you have some pressure but water doesn't flow fast enough to suit you. To make more current flow you have to pump the water with greater force.

This same thing happens to electricity moving through a wire. If the power source can push it with greater pressure, more current will flow. So if you want the locomotive to run faster, you need more electricity, and to get more, the power pack must push with more force. The pressure or force is measured in units called "volts." A pressure of 12 volts will force just the right amount of amperes around the circuit and through the locomotive motor to make it deliver full power.

A pressure of 12 v. (12 volts) is a low electric pressure. It's so low that you cannot get a shock and it is fairly safe in other respects.

The 110 v. pressure of the wall socket is much more dangerous and on occasion has caused death. Not alone because the pressure is great, but because a high pressure forces so much more electric current through the wire, or a motor, or your arm, or anything else that becomes part of a circuit.

Higher pressures are rare in model work, but thousands of volts of pressure are used to force electric current through some radio, television, and power transmission apparatus.

Resistance and heat

When you try to force electricity through any circuit, you have to overcome friction just as real as though you were pushing a heavy carton over a concrete floor. This friction in a wire or other electrical device is called "resistance" and resistance is measured in units called "ohms." Copper wire has low resistance, minimum friction, so we use it for most of our connections. Some other materials have very high resistance and it takes more volts of pressure to push a current through them. Here's what happens in a wire that produces the resistance to electric current:

You may remember when we first talked about electrons I said they danced around at all times. If they dance fast you have heat. If you push a box over a concrete floor you are going to agitate some of the electrons on the bottom of the box and some on the floor. These move around faster so you have heat. If you slide down a rope too fast, this agitation produces so much electron activity that you are burned.

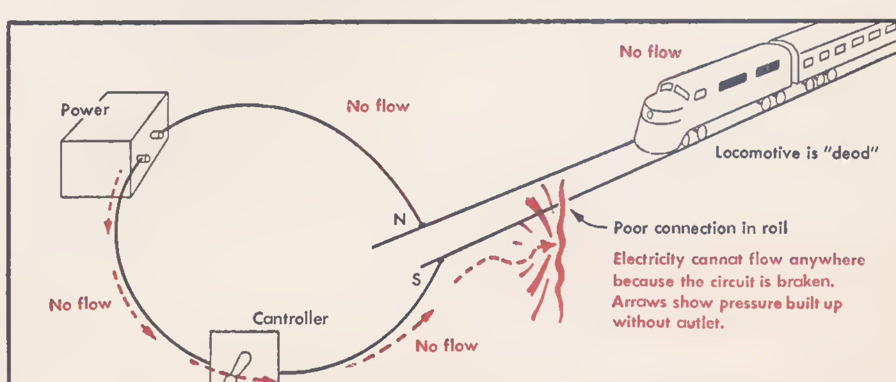
Well then, if electricity means you are merely pushing dancing electrons along a wire, you're going to agitate them this way too. The harder you push, the more current there will be and the hotter the wire will become. This agitation is in the wire, but it is going to bounce against nearby electrons in the insulation and air surrounding the wire. All energy thus lost in heat is never going to help run your locomotives. It is energy wasted where you don't need it.

When a wire is small, the current has to pass through a restricted path and there is much agitation. In this high resistance the wire temperature goes way up and much energy is lost.

If the wire is a big one, the current has lots of elbow room and there is slight agitation—less energy is wasted. That's why we want to use large wire between the power pack and the track, so more energy reaches the engine.

Likewise a long wire has more resistance than a short one and wastes more power.

The kind of material in a wire or any other kind of "conductor" makes a difference just as do the size and



2 - 8 Electricity cannot do work unless its circuit is a complete path. This circuit is "open."

length. Silver and copper are smooth paths for electricity and thus have low resistance, produce little heat.

Iron and lead have a higher resistance, and the electrical friction produces much more heat. Here is a list of commonly used materials to show the amount of resistance in each.*

Relative resistance

Silver	1.6
Copper	1.7
Gold	2.4
Aluminum	2.8
Magnesium	4.6
Tungsten	5.6
Zinc	5.8
Brass	7.0
Phosphor bronze	7.8
Nickel	7.8
Platinum	10.0
Iron, steel	10.0 and up
Solder	16.0
Lead	22.0
German Silver	33.0
Nichrome	100.0
Carbon	900.0 and up

*The values represent the resistance of a wire 100 ft. long and 0.025" (approximately size 22) in diameter at a temperature of 68° F. Resistance rises slightly in most metals when temperature increases; it drops in carbon. Values are in ohms.

You might compare copper wire to a water pipe with a smooth inside wall. Water flows through the pipe easily and electricity does the same through copper.

Iron wire isn't as good a conductor; you could compare it to a rusty pipe stuffed with a lot of steel wool. Water has to be pushed pretty hard to get much through. The same holds true for the iron wire. If you want much electricity to flow through, you have to push harder — apply more volts of pressure.

As a matter of fact, the amount of current you can get through a metal conductor is directly proportional to how hard you push it. If you have a copper wire that resists current with 1 ohm of electrical friction, it would take 1 v. of pressure to force 1 a. of current through. Increase the pressure to 2 v. and 2 a. will flow.

In the same way, the resistance also affects the current in direct proportion. If you have a 1-ohm wire and 1 v. passes 1 a. through, it would take 2 v. to force 1 a. through 2 ohms of resistance.

These effects are neatly summed up in a mathematical formula called "Ohm's law." You may occasionally have use for the rule, but there is little need to try to memorize it or even understand it. Here's how it looks:

Let

I represent current in amperes

R represent resistance in ohms

E represent pressure in volts

Then

$E = IR$

Which means that if you want to push a current through a circuit or part of a circuit, you multiply the desired current, in amperes, by the resistance, in ohms, and the product is the required pressure in volts.

You can use this formula in three ways depending on which of the three terms, I, R, or E, is the unknown. Here are the other two forms:

$R = E/I$

$I = E/R$

Which mean you divide either current or resistance into pressure to find resistance or current.

Notice in our table of materials that all except carbon are metals. Electricity will also pass through many other materials if they are damp. Pure water will not pass electricity very well, but add some salt or an acid or many other chemicals and you have a fairly good conductor.

Most plastics, wood, fiber, paper, cloth, porcelain, waxes, and cements are very poor conductors when dry. Their resistance is a matter of millions of ohms, and so little electricity passes through them that we call them "insulators." In model railroad work you can choose your insulating material for its mechanical advantages and not worry about how much power is wasted in heat. The amount is negligible.

The art of electric control is merely a craft of using suitable conductors and insulators to guide electric energy where you want it and to convert it into useful work.

Summary

Before we study the individual parts of our control circuit, let's pick out the important points we have already discussed, so you can refer to any of them quickly later on.

A. Be sure you draw your track plan with all the turnouts in the right places.

B. Keep the plan handy.

C. You can wire any kind of track plan.

D. Wiring for several trains merely repeats parts of the simple pattern for one train.

E. Electricity flows through metals and damp materials.

F. Electricity doesn't flow through air, wood, plastics, and other insulators very well.

G. Current must pass *through* a motor to make it run.

H. An electric circuit must be a complete, connected chain of conducting materials before a power source can force electric current around it.

I. Item *H* is a clue to many troubles as well as a principle of design.

J. When electricity passes through one element and then through another, the elements are in "series."

K. When current divides and part passes through one element and part through another, the elements are in "parallel."

L. The "ampere" is a unit of electric current.

M. The "volt" is a unit of electrical pressure.

N. Pressures of 110 v. are much more dangerous than those of 12 v.

O. The unit of electrical friction or "resistance" is the "ohm."

P. When current passes through any resistance, some energy is converted into heat and wasted.

Q. All materials have some resistance.

R. Big wires have less resistance than small wires of the same length and material.

S. Copper is a practical conductor. Other good ones are silver, gold, and aluminum. Brass is fair — solder and lead are not nearly as good.

T. The amount of current you move through metals is proportional to the volts of pressure you apply.

U. If a circuit has more resistance, it takes more pressure to force the same current through. Again this is in direct proportion.

V. Ohm's law is a handy formula for finding the unknowns in current, resistance, and pressure relationships.

The Power Source

NINE model railroaders out of ten will be wise to start with a small power pack that furnishes 2 a. to 5 a. of current at 12 v. pressure. This pack costs less than a locomotive and it will supply enough power to run one or two medium-size engines easily.

You might think it better to buy a big pack so you can handle many trains later on, but this isn't the best idea. A big pack will save a little money in the long run, but it will not run the trains as well as several small packs. This is because each time you start another train all the others slow down if they all get their power from the same pack.

When you start with a small pack, your first cost is low at a time when you need cash for other model railroad materials. Then later on as you add more trains you also add more small power packs and at the same time get the best possible power supply.

This idea is called "multiple power supply" and I'll tell you how it compares with "twin power supply" and "single power supply" in chapter 17. Until you're ready to run more than one train there's no difference between these systems.

If you want to figure how many locomotives a pack will handle, you can figure roughly 1 a. to a locomotive motor unless large-sized motors are used. If you want to be exact, use the table on page 13. Figure all the motors you will run from one pack at the same time and add them up to see how much current your pack must furnish.

Storage batteries and generators are usually too much trouble for any advantages they offer except for club-sized railroads or systems on farms away from power lines.

You cannot use a toy train transformer to run scale model railroads because transformers produce the wrong kind of electricity.

The output of a transformer is "alternating current," usually just called A.C. In a wire carrying A.C. the electrons flow in one direction for a while and then they stop and move the other way for a while. This alternating goes on so fast that the electrons swing forward and back many times every second.

If the current swings fore and aft 60 times every second we call it "60-cycle A.C." This is the "frequency" of the A.C. in most parts of our country but not everywhere.

A toy transformer may produce around 12 v., but it is still not suitable because the current alternates and the motor in a scale locomotive will just sit and cook if you try to use it. Our motors need D.C. (direct current).

You can buy a device called a "rectifier" to attach to the toy transformer and the rectifier will change the A.C. into D.C.

The rectifier acts as a sort of traffic regulator and sends all the electrons around the circuit in one direction even though they come out of the transformer going alternately both ways, Fig. 3-1.

A transformer and a rectifier are exactly what you get when you buy a power pack, but you also get the convenience of having the whole works in one box and some added features as well.

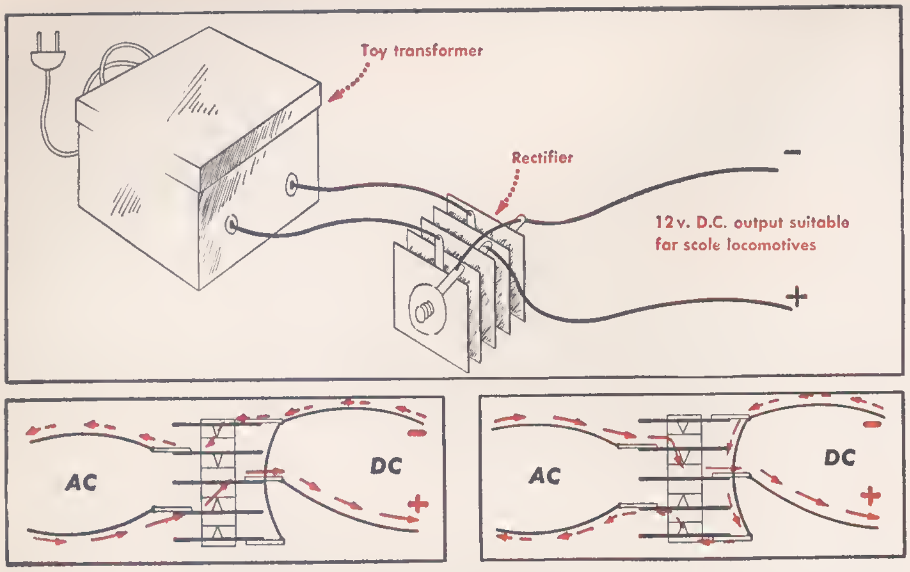
One feature every power pack should have is a fuse or a circuit breaker. Either device will break the circuit whenever the current gets too strong. This protects the wiring and electrical parts from getting too hot, as I'll explain later. If a circuit breaker is not included you can add one yourself.

The circuit breaker is better than a fuse because you can use it over and over again. A fuse blows once and you have to install a new one. This isn't much trouble except that you must always keep a spare supply on hand. The fuse or circuit breaker should be rated at the rating of the pack or up to double this value, but never more than 10 a.

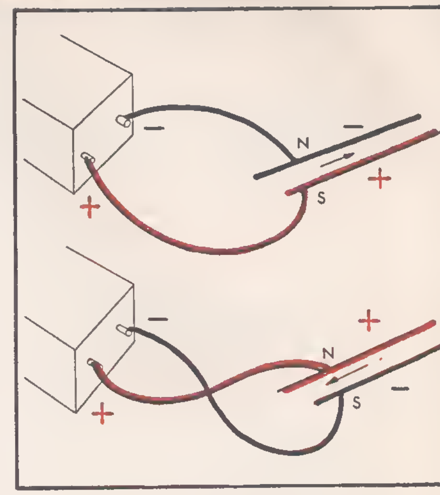
When you buy a power pack, be sure it is rated for use in your community. This is usually an input of 115 v. 60 cycles, but might vary from 110 v. to 125 v. Other voltages or less than 50 cycles require a special pack.

On the West Coast many cities have 50-cycle A.C. and this is so little different that model railroaders can ignore the variance. In upper New York 25-cycle A.C. is used and special

This cantral panel controls John Seabraak's large railraad near Bridgetan, N. J. Now Jahn is building a new railroad with cab cantrol and the new panels will da mare with fewer parts than the sectian cantral scheme used in this phata.



3 - 1 The upper illustration shows how to connect a rectifier to a toy transformer to convert A.C. into the D.C. you need for scale model railroads. The inside of a power pack contains a rectifier and a transformer connected in this same way. If you use a selenium rectifier, adjust the transformer to supply 16 v. to 18 v.; but if you use a copper-magnesium-sulphide type of rectifier, the transformer should be adjusted for 25 v. In this case the polarities of the output will be reversed. The two small drawings show how a rectifier directs opposing pulses of A.C. the same way around a D.C. circuit. The diagrams represent an interval 1/120 of a second apart.



3 - 2 One way to reverse track polarity is to interchange the feeder wires. This will make a train run westbound instead of eastbound.

transformers and power packs must be used.

Also buy your pack from a dependable dealer so you know what you are getting. The dealer will probably know about the quality of the pack, about its regulation, output voltage at no load and full load, and other things that affect quality. If you're using my advice to run only one train per power pack, the regulation will not matter and you can save some of the cost.

It is a good idea to get a pack with an on-off toggle switch. This saves having to pull the plug when you are through running trains for an evening. There may also be a throttle and direction controller toggle (reverse switch) built into the pack. This is fine if you are going to use the pack for only one train and if you like the way the controls are arranged.

If you plan to run two trains from the same pack, it is better to have separate speed and direction controllers located on a control panel away from the power source.

A pack with built in direction controller also is not as easy to use when you have a turning track as you will see in chapter 9.

Some packs have extra connections to supply power for switch machines and other accessories. These will save money at first but are not a final answer. A separate supply for switch machines would be better.

The full load voltage of a power pack should never drop below 12 v. This means a pack with a very light load will put out around 16 v. (which does no harm to your equipment as long as you run at scale speeds).

All output terminals on your pack should be clearly marked. If they are not, have your dealer test with his meters and draw a diagram so you can mark the terminals later.

One terminal should be marked +12 v. The other may be marked —12 v. or just —. If there are A.C. terminals for accessories, they should be marked 18 v. A.C. and 0 v. A.C. or some other way to distinguish from the D.C. power. If the pack has a direction controller toggle, throw it to the right (or down) when you test for polarity.

The relation of plus to minus (or positive to negative) of a D.C. circuit is often very important. In the old days we thought electricity flowed from the + terminal around the circuit to the — terminal of the power source and that is still the way we speak of the current. In actuality, we found we'd made a bad guess, for the electrons really move from the — toward the + pole. It is our naming of the terminals that is really wrong, of course, not the electrons. But the custom has been used too long to be changed easily.

When we interchange the connections of a circuit so current flows in the opposite direction, we say that it is a change of "polarity," Fig. 3-2.

Summary

A. A small 2 a. to 5 a. power pack is the best to start with in most cases.

B. The only advantage of a large pack is long run economy.

C. You cannot use a transformer alone to run scale locomotives, but you can add a rectifier so the output becomes the necessary D.C.

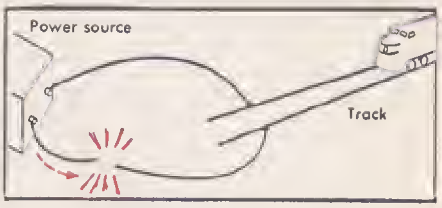
D. Alternating current, A.C., is an electric current that changes its direction of flow many times a second.

E. A power pack should have a fuse or circuit breaker.

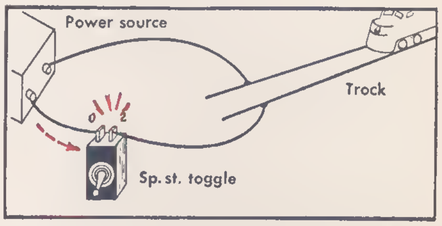
F. The full load voltage of a pack should not drop below 12 v.

G. The output terminals of the pack should be marked to show voltage and polarity.

Speed Control



4 - 1 A broken circuit stops the train.



4 - 2 An on-off toggle is a more convenient way to stop a train, but all it really does is break the circuit.

GOOD train performance depends on the quality of the parts in your control circuit, but it also depends upon how you handle the locomotive.

The principal controls an engineer uses in a real locomotive are the throttle, brake, and reverse gear. The throttle sends power to the drivers for starts and continued running. The brake drags against the turning wheels and slows or stops the train. The reverse gear is used for backing, but on a steam locomotive it also controls the efficiency with which the steam is converted into power. See photograph on page 11.

You can build a cab with these same controls, but most model railroaders are satisfied with a simpler arrangement. This includes a speed controller that combines the throttle and brake in one handle, and a toggle for changing direction from eastbound to westbound or vice versa. This is not quite the same as "backing up" as you will see in chapter 5.

The speed of your train depends upon the load the engine pulls, and it also depends upon how much current you push through the motor. Force a normal current through the motor and the engine will run as fast as it should considering the load behind it.

Suppose we deliberately break a wire in the feeder system as shown in Fig. 4-1. Now one of the paths is interrupted and current cannot pass *through* the motor even though the other path is intact. The train stops dead in its tracks and won't go until you restore the connection and make the circuit complete.

When we want to open a circuit and close it at will, a break in the wire isn't convenient so we use an electric switch such as the simple toggle shown in Fig. 4-2.

This kind of toggle is called a "single-pole single-throw" or sometimes just an "on-off" switch. The abbreviation *sp. st.* is used in catalogs and that's what we shall use in this book too.

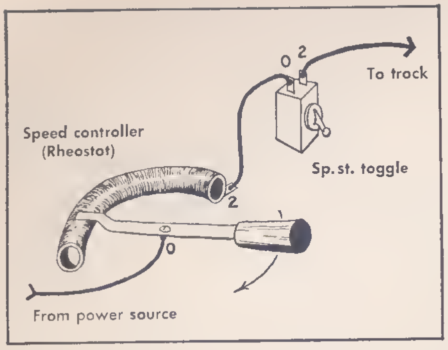
Since the word *switch* can be confused with track switch, I'm going to use the words *toggle* and *turnout* most of the time. But you can always substitute any kind of sp. st. switch or contacts whenever I refer to an sp. st. toggle. The only thing to watch for is that the contacts of the switch or toggle are rated to handle at least as many amperes as will pass through your circuit. This is usually the case.

The sp. st. toggle is fine for cutting power in a circuit — and that's what we'll use it for later on. It isn't good enough for controlling a locomotive because it stops the engine too suddenly. What we need is something with a more gradual action and the device most often used for this is a "rheostat." See the photo on page 10.

A rheostat produces electrical friction that wastes power. The more power it wastes, the less power is left to run the train. Thus, as you turn the handle on a rheostat, your train moves more slowly until it finally stops.

A rheostat consists of a small coil of resistance wire wound around a heat resisting form such as porcelain. One edge of the coil is polished clean, and

A cab like this will add a lot of fun to any model railroad. Ed Spinney has his hand on the throttle. Just below is the reverse quadrant. The whistle cord is at the top. Once you have your railroad running smoothly projects like this can be added at your leisure. You can even make a "controlled acceleration" type of throttle that makes a train start very gradually. The idea is to drive the rheostat with a motor.



4-3 When a rheostat has no off position, an on-off toggle should be provided so current will not flow while a locomotive is standing. Notice this rheostat is a different shape from the one in the photo below, but both work on the same principle. Other rheostats are made on straight tubes with wires that lead to a multi-contact switch.

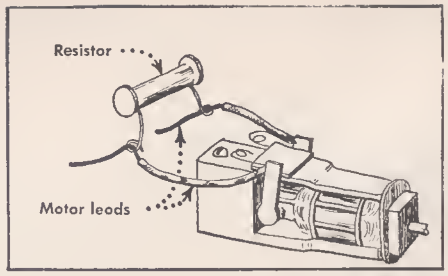
a metal or carbon wiper slides over it from one end to the other.

Most rheostats are designed so the wiper doesn't touch any metal at the "off" end. This cuts all flow of current and the train will not run.

Some rheostats are made without the off feature and then you must connect an sp. st. toggle in series, as in Fig. 4-3. The idea is to prevent any current from flowing through after the train comes to a stop. If a small current should flow through a stalled motor, the motor might overheat and be damaged.

When you turn either type of rheostat on, the wiper rides over the coils of resistance wire and less and less power is wasted. Soon you reach a point where enough current enters the motor to start it turning. From here on the train runs faster as you turn the throttle.

At the extreme "on" end all the re-



4-4 A fixed resistor across the two wires leading to the motor will help if the engine will not come to a smooth stop. Solder the two pigtail leads of the resistor to the motor leads. If one motor lead is grounded you may also connect one end of the resistor to the frame. The resistor may be tucked into almost any small space inside the loco.

sistance wire is by-passed and the motor receives all the electric current it is designed to handle.

Rheostats are rated two ways — in ohms, for their maximum resistance, and in watts, for the amount of power they can waste safely.

You should pick the ohms value to match the smallest motor you are going to run, but the watts rating should be large enough to handle the largest load.

For most small and medium-size motors a rating of about 40 ohms is just right. Less than this will not stop some engines when running light.

In O gauge, 20 ohms is more often used because small motors are rarely run in this gauge. Very large O gauge motors can be controlled more easily with a rheostat of only 12 ohms.

For single motor trains a 50 w. rheostat is adequate. If you want to run double headers or two-motored engines frequently, or two trains from the same rheostat, you will be better off with a 100 w. or even larger rheostat. This idea is better than trying to fasten two rheostats to the same shaft.

Some manufacturers now rate rheostats by their ampere capacity instead of the older watt method. This is safer because you know exactly how much load you can control. Add up the total load in amperes just as you did for power packs, page 7. This time, of course, you add up the total of the load that will be controlled by this one rheostat. Then the ampere rating of the rheostat must be at least as great.

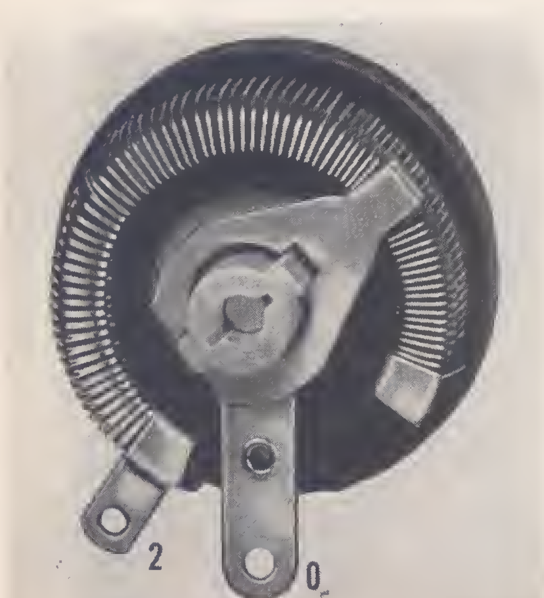
If you have a locomotive that will not come to a gradual stop even with a 40-ohm rheostat, get a 50-ohm 5 w. (or 10 w.) fixed resistor at a hobby or radio supply store and connect it in parallel with the motor in the engine, Fig. 4-4. If the engine still persists, change to a 25-ohm 10 w. resistor.

An ordinary rheostat works like a radio knob, but there are levers you can attach to make the operation more realistic. Some clever throttle type rheostats are sold especially for model railroad use and are much more realistic to use.

I like to locate the speed controller for left-hand use just as in a real locomotive. This leaves your right hand free to help couple cars or do any other jobs within reach.

Often speed control is included as a part of the power pack, and some packs have more than one rheostat for handling several trains. Then, of course, it isn't necessary to provide a separate rheostat.

If you are anxious to get your railroad running, you can go from here to the next chapter. The rest of this chapter tells you more about what happens in your electrical control circuit and perhaps will be more of a help in the future than right away. If you do have the time to read it now, so much the better.



Most rheostats look like this from the back side. Electricity enters at the terminal lug **0** and passes to the central moving wiper. This slides over the coil of resistance wire. Current leaves via lug **2**. A shaft protrudes from the other side and you can fasten a knob or a controller handle to the ¼" shaft. The wide block place at the lower right is where the wiper can rest when trains are not running. As you turn the controller on, the wiper first reaches a section of small wire. Later heavy wire is cut in. This "tapered" feature makes a rheostat better able to carry heavy currents when trains are running at nearly full speed. This particular rheostat has three sizes of wire as you can see in the photo. The numbers **0** and **2** are used in this book merely to help get connections straight if you must make a substitution.

How speed control works

The speed of the motor in your locomotive depends upon the load it must pull and upon the amount of electric current passing through it. If the load is heavy, you need more current to pull it. If you want to slow down, you need less current. Thus, we control the speed of our trains by changing the amount of current flowing through the motor.

In chapter 2, I said that the amount of current flowing around the circuit depends upon how hard you push it. Then if you push with only 6 v. instead of 12 v., the motor should get only half as much current, say ½ a. instead of 1 a.

And if the motor has only half as much current, it should run more slowly.

How slowly does it run? It runs at less than one-quarter of its normal

This cab is in a Pennsylvania RR. steam locomotive. 1 is the throttle while the reverse quadrant, 2, is almost hidden behind the independent brake, 3. This brake has no effect on cars, but the automatic brake, 4, at engineer's hand, operates the cars as well as the loco and tender. The radio-phone, 5, is just coming into use for talking to the caboose and sometimes to wayside stations and passing trains. The cab signal, 6, tells the engineer and fireman about track conditions regardless of outside visibility. The four aspects are (reading from top to bottom): green, yellow-over-green, yellow, and red. Two windows are used for the yellow-over-green. On the Pennsylvania rows of white dots at different angles replace the colors.

speed when the current is cut in half. This may seem strange at first because you might expect the motor to run at half speed. The reason is that not only does the motor have just half as many electrons passing through, but the push behind them is only half as much — 6 v. instead of 12 v. If you have only half the current and half the pressure, you can do only one-quarter as much work.

This relation among current, pressure, and power is just as useful as Ohm's law. In practical terms it is:

Power (in watts) = amperes (of current) times volts (of pressure)

Or, if you prefer the letter symbols:

$P = IE$ where P is power in watts. Watts are the units of electric power whether the power is useful or wasted in heat.

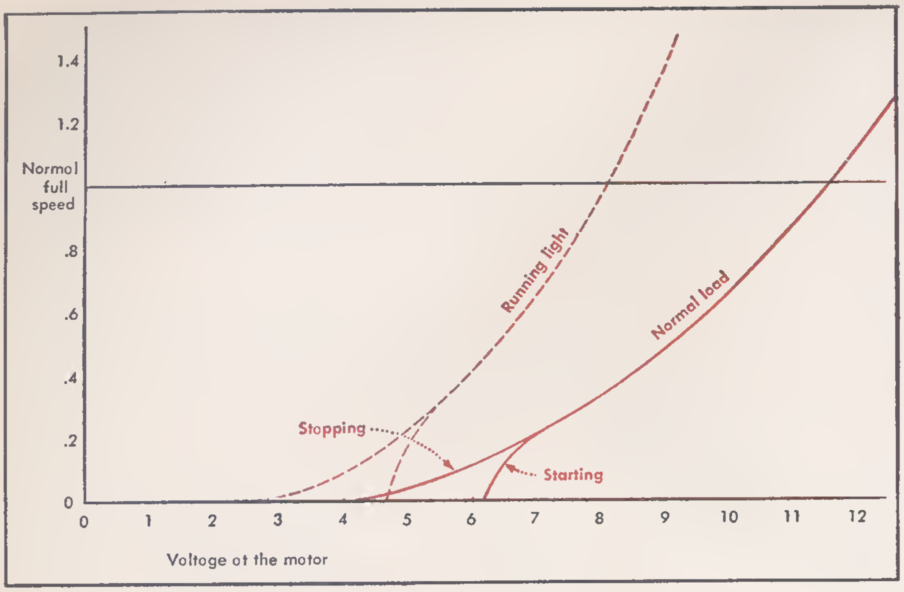
Now in our original motor, when it went full speed at 12 v. it drew 1 a. of current from the power source. Since 12 times 1 is 12, we know the motor used 12 w. of power. This is a lot less than most light bulbs use and much less than that required by a flat iron.

How much did the motor use when it had half as much current and half as much pressure? The motor used only 3 w. of electrical power because 6 times ½ is 3.

All this 3 w. of electrical power is supposed to go into mechanical power to pull the train. Actually this doesn't happen — some power is wasted as friction in the engine, some as electrical and magnetic friction in the motor. All three kinds of friction produce heat and thus not all the power helps to move the train. That's why the engine will run at less than one-quarter normal speed.

As a matter of fact, if you reduce the pressure to less than 6 v. you will reach a point where the motor stalls even though some current passes through it. With a light load and a well-designed efficient motor this may be at as little as 2 v. pressure. With most motors, stalling more likely will occur at around 4 v.

Fig. 4-5 shows a typical graph of speed vs. voltage for a motor in a locomotive. Most motors behave like this but the actual numerical values may be different.



4-5 Once started, motor speed increases rapidly with voltage.

Three kinds of power

Now here's something important. We use a motor to convert electric power into mechanical power. Much of the electricity we send to the motor develops mechanical power, but we've seen that some of it doesn't.

There's a lot of waste going on and all of it is turning into heat. Two of the most important problems an electrical engineer has to solve in any project are: "How shall I keep the wasted power to a minimum," and, "Will the wasted power produce so much heat that my equipment will be damaged."

Most of these problems are already solved for us. The motor designer determined just what size wire to use so your motor would deliver as much power as possible without overheating at 12 v.

The power pack designer used the proper size rectifier and transformer to deliver dependable power at the rated current without overheating.

And so it goes down the line of specialists who take the headaches out of the hobby for us.

Sometimes we have to take the role of engineer, too. When the power supply delivers 12 v. to the feeders, we have to be sure that the bulk of it gets to the locomotive. Our feeders cannot waste too much power or the motors will not get their full share for full-speed operation. That's a problem we'll dicuss in chapter 6. Sometimes we must choose the right size part so it won't overheat. We'll solve that problem in other chapters, but I'll give you a general idea of it here.

Heat dissipation

Some of the electric power we send to a *motor* is converted into mechanical power; the rest is wasted in heat. In a rheostat *all* the power is wasted in heat. Thus, when you say "50 w. rheostat," you mean "this rheostat is big enough to dissipate 50 w. of electric power without getting too hot."

How hot is too hot? Too hot is that point at which damage is about to occur. It depends on the material of which the rheostat or any other part is made and how well it is cooled. In open air a part is well ventilated and it can dissipate its rated power, in this case 50 w. Turn on a fan and you have better cooling; now the rating goes up. You might be able to dissipate 100 w. or more if the air blast can reach all through the part.

Put the device in a box such as a control panel and ventilation is cut off. Now maybe only 25 w. or less can be dissipated safely.

This applies to all electrical devices and heat dissipation is usually the only thing that limits the power you can force into an electrical part. Here are some points to remember about heat.

The watt rating of a part assumes it will be located in free air.

If a part is to be used in a control panel or other closed space, use a higher watt rating than normal.

The current rating of a power source also is limited by the heat dissipating ability of the source.

The voltage rating of a motor is likewise determined by the heat, but in this case it is assumed that the motor will be used in a locomotive shell. The rating is supposed to allow for the poor ventilation.

The reason motors are rated in volts and power packs in amperes is only a matter of convenience. The watts of heat wasted are the real limit factors in each case.

If you don't know the watt rating of an electric part, compare it with another part of similar size and materials. Usually the two will have about the same rating even though the voltage needed to produce the watts might be different. A part with a dark, rough surface can dissipate more heat than a light-colored polished surface. These things all make a difference as do ventilating fins. You should also consider whether or not the material is easily melted, charred, or distorted by heat.

Watts and ohms co-operate

Before I finish let me point out how useful the watt relation and Ohm's law are when you want to find out "what cooks" in your electrical equipment.

Ohm's laws were stated:

$$E=IR \quad I=E/R \quad \text{and} \quad R=E/I$$

Similarily you can learn about power in three ways:

$$P=IE \quad I=P/E \quad \text{and} \quad E=P/I$$

And you can go a step beyond this and relate power to resistance:

$$P=I^2R \quad P=E^2/R$$

Which shows that power increases as the square* of the voltage or current in any particular device.

With these relations you can figure out not only how your motor is behaving, but also how the rheostat and track feeders affect the circuit.

In our example of the motor using only ½ a. at 6 v. you can also find out what is happening in the rheostat. First we know the current in the rheostat is also ½ a., because the same current passes through both the motor and the rheostat. All elements in a series circuit receive the same current.

Then we know that if the power pack produces 12 v. and the motor uses only 6 v., there must be another 6 v. wasted in the rest of the circuit. Let's allow for 1 v. waste in the feeder wires (this can be calculated, too, if you want to be that exact). This leaves 5 v. of pressure for the rheostat. Then by Ohm's law we'll find the rheostat must be turned to a point where exactly 10 ohms of resistance wire is cut in. This is one-fourth of the full 40 ohms, so if the rheostat is an ordinary type, the handle must be three-fourths of the way on.

You also can see how much heat the rheostat is producing — this time it is the watt law; 5 v. times ½ a. equals 2.5 w. We are using one-fourth of the entire 50 w. rheostat or 12.5 w. worth

*The "square" of a number is the number multiplied by itself. Thus, the square of 5 is 5 times 5 or 25. A small ^{2} raised above a number indicates that you should "square" it to work out the problem — $5^2=25$.

Current Ratings of Motors

Moke	Models	Normol Current in Amperes
All-Nation	DC-941, DC-942	1.0
	DC-951, DC-952	1.0
	AC-941, AC-942	1.0
	AC-951, AC-952	1.0
American Flyer	HO	0.85
(Gilbert)	Add far smake unit	0.30
All madels	S steam (small)	0.85
with lamp	S steam (large)	1.5
	Add far smake unit	0.4
	S diesel, ane-motor	1.25
	S diesel, twa-matar	2.25
Bowser	506A, 506B, 606A	0.7
Kemtran	KL766	0.3
Kendrick & Davis	117-1	2.0
(K&D)	117-2	2.8
	117-3	4.0
	117-4	5.0
Lindsay	L170, L180	0.8
	L1010, L1030, L570	0.5
	L1045	0.8
Labaugh	6100	1.75
	6200	2.75
	6300	4.0

Moke	Models	Normol Current in Amperes
Mantua	PM1	0.6
Miller	One-matar truck	1.0
	Two-matar truck	2.0
Current shauld be lawer while running		
Model Pike	DC-60	0.7
Nord	M1	1.35
Pennsylvania Scale	PCC, Indiana	0.3
Pittman	DC-60, DC-62	0.6
	DC-702 (RDC car)	0.5
	DC-71A	0.8
	DC-80	0.85
	DC-91	1.3
	DC-92, DC-94	1.2
	DC-93, DC-95	2.0
	AC-92, AC-94	1.75
	AC-93	2.0
	AC-95	2.2
Scale Craft	OO, 1950 model	1.5
Thomas	L1-44	0.75
	L2-45	1.3
Varney	V2, V3, V4	0.75

These ratings are the normal current through a motor while operating at 12 v. D.C. with proper load. Stalled motors may draw more current and thus be damaged by excess heating. In most motors the maximum safe current is from 25 to 33 per cent above the normal current. This would represent the conditions of operation at 15 v. D.C. or with a more than normal load at 12 v. Motors designed for A.C.-D.C. service will draw approximately the same current when operated at 16 v. A.C. instead of 12 v. D.C.

of it to dissipate only 2.5 w. so that should be plenty safe.

Summary

A. An sp. st. toggle is fine for opening a control circuit, but it does not produce any gradual effect.

B. You can substitute one kind of sp. st. toggle or switch for any other as long as its current rating is high enough.

C. A rheostat usually combines the effect of an on-off toggle with the effect of a variable resistance. By wasting power, the rheostat can reduce the current and thus slow the locomotive.

D. A rheostat of around 40 ohms and 50 w. or 100 w. will satisfy the needs of most model railroaders.

E. The speed of the motor in your locomotive depends on the load it pulls and the current passing through.

F. The power converted by a motor or any other electrical device is proportional to the current and the pressure. This may be expressed as:

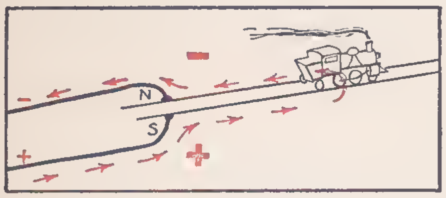
$$P = IE$$

G. In any electrical device some or all the power passing into it is converted into heat. This is usually unimportant on a model railroad as long as damage does not occur.

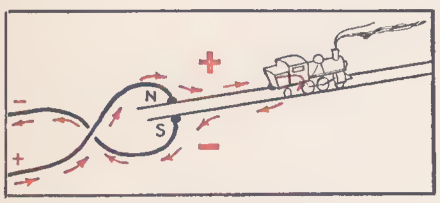
H. The watt rating of a part depends on its heat dissipating qualities such as ventilation, size, color, surface, and where it is located.

I. If you know any two of the four quantities, volts, amperes, ohms, watts, you can find the other two.

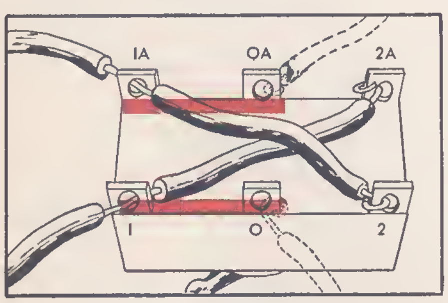
Direction Control



5 - 1 When the S rail is positive trains will be eastbound.



5 - 2 When the S rail is negative trains will be westbound. This is true regardless of which way the cowcatcher points.



5 - 3 Whenever a double-pole double-throw toggle is used for reversing polarity, crossed wires are added to it as shown here. This is a rear view. When the toggle handle points to the left, terminals **0** and **1** are connected together as are terminals **0A** and **1A**; color shows this internal connection. Throwing the handle the other way connects **0** to **2** and **0A** to **2A** instead. You can substitute other kinds of dp. dt. switches. Label the terminals to the moving poles 0 and 0A in this same way. Then number the fixed contacts in the order of their use.

IN ALL of our diagrams so far I have shown the electricity going around the control circuit in a counterclockwise direction. Suppose we made the electric current flow the other way around.

With ordinary motors this wouldn't make any difference. But motors for scale model locomotives are usually designed so that they will reverse and turn the other way when you "reverse" the polarity of the electric current, Figs. 5-1 and 5-2.

Notice how I managed to get the electricity to flow the other way around in Fig. 5-2 by interchanging the wires before they reach the track.

Reversing an engine this way is just as awkward as it was to start and stop it by breaking a feeder wire, so again we resort to a toggle switch.

This time we're going to use a toggle called a dp. dt. (double-pole double-throw), and we must add two short wires to the back of the toggle as shown in Fig. 5-3.

Now if you connect the toggle as in Fig. 5-4 and then throw it as in Fig. 5-5, you have crossed the feeder wires to make electricity go the other way.

At first you might think you were "reversing" the locomotive and be tempted to call this toggle a "reversing switch." After all, you throw the toggle one way and the engine moves to the right. Throw it the other way and it moves to the left. Isn't that the same as backing up?

No, it isn't, and you can prove why by picking up the locomotive and turning it the other way. Now when you have the toggle to the right, the engine still moves to the right and this time it's backing to the right instead of going forward to the right.

So this toggle controls direction, not reversal, and it is better to mount it in a horizontal position rather than a vertical one on the controller unit panel.

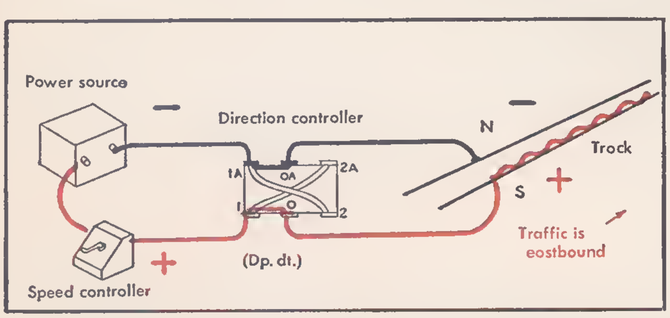
The term "reversing switch" is still used for a direction controller and that's OK as long as you realize that what really happens is not strictly reversing.

There is an easy way to add the crossed wires to the back of the dp. dt. toggle. Remove 1½" of the insulation from two of the connecting wires. Slip one of the connecting wires through the terminal lug at one corner of the dp. dt. toggle, and then wrap a short piece of friction tape around the wire where it was stripped. The last ½" or so should be left bare and pushed through the opposite lug. Now solder both corner lugs and then add the other crossed wire in the same way. With some kinds of insulation you can save a small tube and slip it over the wire instead of taping it.

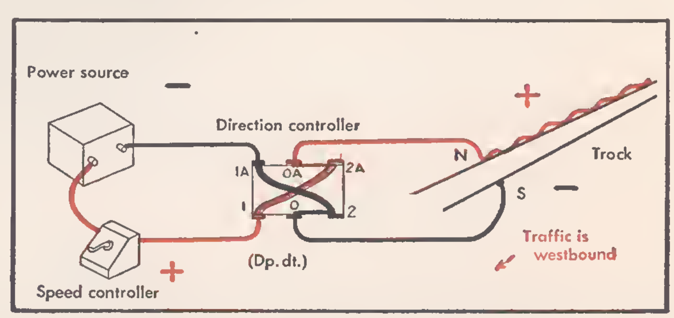
Again, as before, you can substitute any kind of dp. dt. switch for the toggle as long as it will carry the current. A 3 a. rating will do for all but railroads running large locomotives or several locomotives from the same toggle. Then you need 5 a. or more in the rating of the toggle.

You can buy dp. dt. toggles that have an off position in the center of the handle's throw. These make it unnecessary to add a separate toggle for quick emergency stops. The center-off feature is fine in most cases but not with twin power supply, a system for larger railroads which I'll tell about in chapter 17.

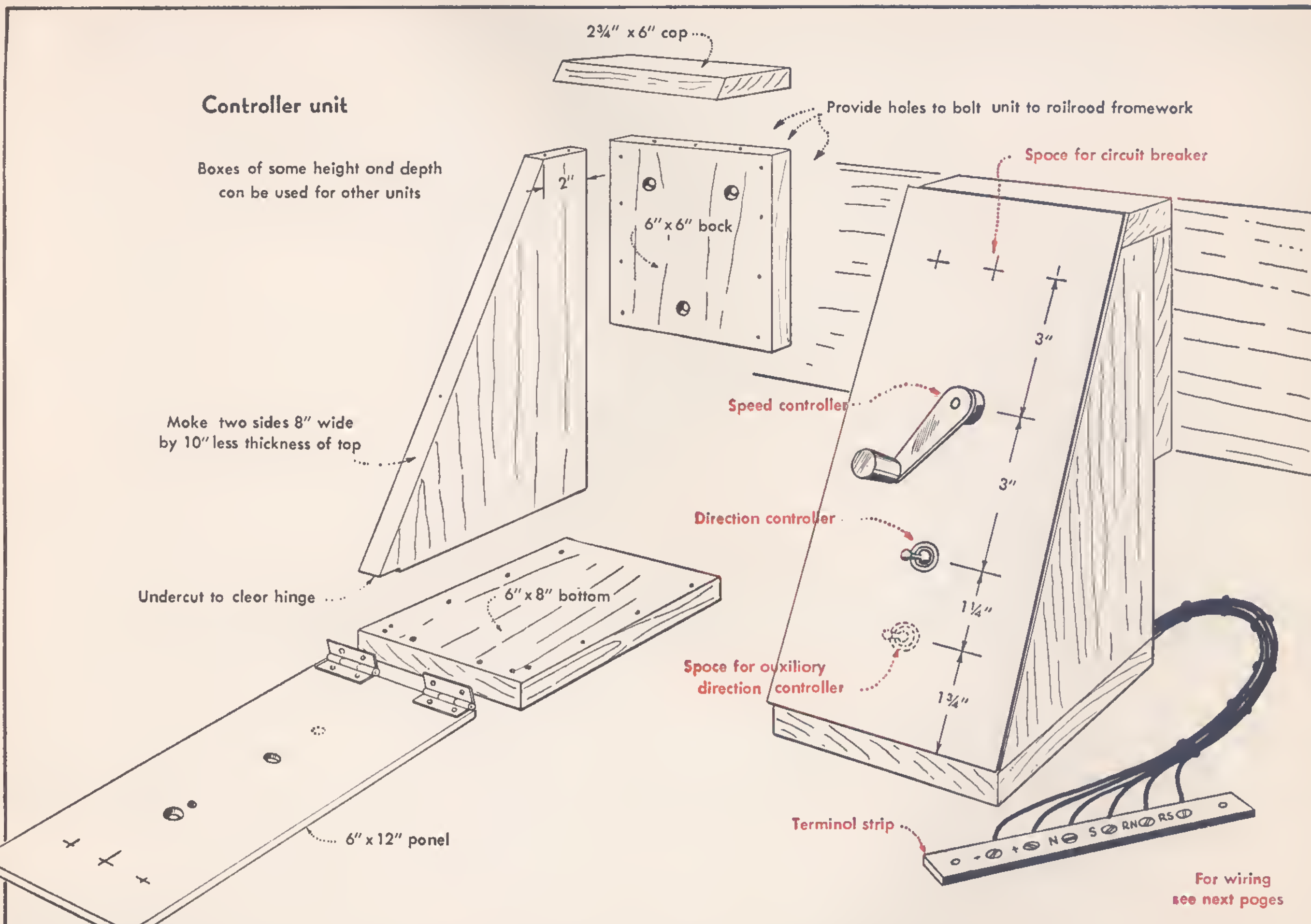
When you throw the handle of your direction controller, it isn't convenient to call it "forward" and "backward" as I have already pointed out. A better terminology is to label the toggle "eastbound" and "westbound."



5 - 4 For eastbound travel, the direction controller toggle sends positive energy to the S rail of the track. The short conductor from 0A to 1A is the contact inside the toggle. 0 to 1 is the same.



5 - 5 To reverse polarity, the toggle can direct electricity through the crossed wires. Now trains run west and the contacts inside the toggle have moved to the right. The toggle is shown from the rear.



5 - 6 The dimensions for this controller unit can be used for wider boxes to hold other control equipment. It is much more convenient to have the panel hinged at the bottom instead of the top. The hinge and terminal strip should be arranged so that the entire panel front and wiring can be removed to a workbench. On page 20 you will find this unit illustrated with all the other equipment you need to run a one-train railroad.

The controller unit

The combination of throttle and direction controller is the control panel for one-train operation and the panel is called a "controller unit" to distinguish it from other units you'll add later on to handle more trains.

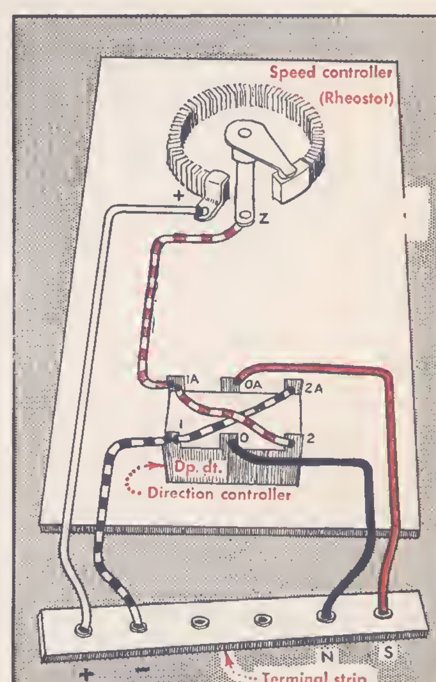
I've mentioned that the controls may already be built into your power pack, or you can buy a controller unit ready to connect to your railroad, or you can build your own according to your own ideas. The box shown in Fig. 5-6 has worked out very well for me because it is easy to make, yet provides a sloping panel and plenty of room inside. You'd be surprised how much difference a lot of room makes when you are ready to add the wires. You can make other boxes with the same dimensions but wider for controlling switch machines and other apparatus later on; this idea of using a separate box for each kind of control job will keep things simple and easy to develop.

Fig. 5-7 shows the simplest way to wire this panel. This is adequate for some small railroads but more often than not you may need a second direction controller as in Fig. 5-8. This "auxiliary direction controller" is needed to control direction at loops, wyes, turntables, and other turning tracks. Chapters 9 and 10 will show if you need the extra toggle but no harm is done if you include it right away. Then your controller unit is good for any track plan, even one you might build five years hence.

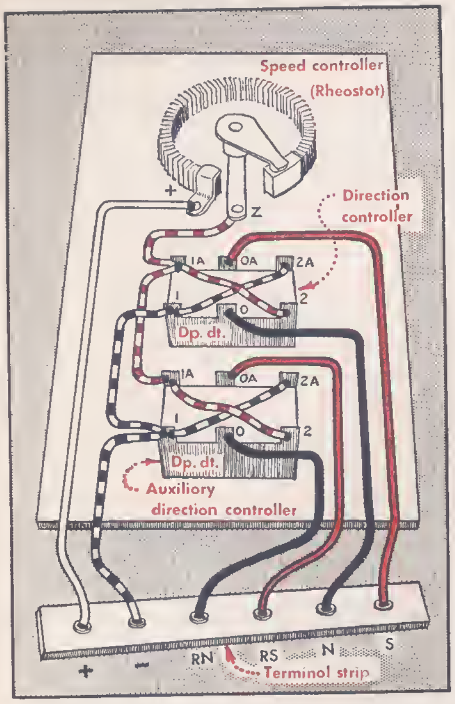
In some ways a controller unit is like an automobile. Your favorite car would still get you downtown even if it didn't have a self-starter, heater, radio, chrome trim, or speedometer. And a simple controller unit like the ones just illustrated will run trains for you very efficiently, too. But, as in the case of the auto, you may someday want to add refinements to your controller units to make train operation smoother or more interesting. Here are some suggestions.

Overload protection

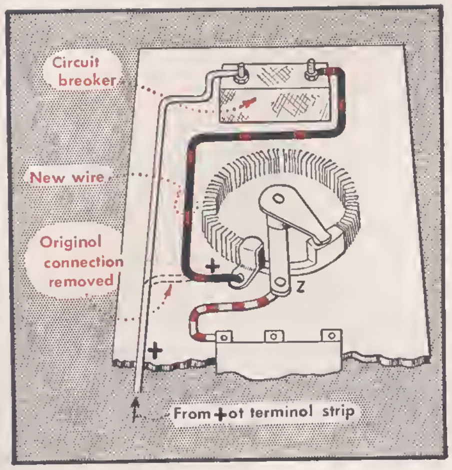
It's a nuisance to run to the power pack to reset a circuit breaker or replace a fuse, so why not put another circuit breaker on the controller unit? Give this one a rating just high enough



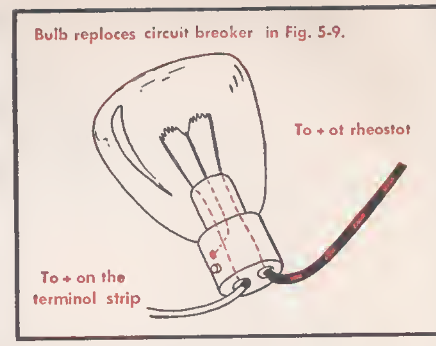
5 - 7 Here is the wiring for the controller unit illustrated above. The four wires to the terminal strip should be 18" to 24" long so that the strip can be fastened to the framework.



5 - 8 In chapter 9 or 10 you may find that you have a turning track. If you do, you must add a second direction controller toggle to the controller unit as shown here. It is wired just like the first toggle. See also Fig. 5-7.



5 - 9 A circuit breaker might be one of many different shapes but in all cases you connect its two terminals like this.



5 - 10 An automobile head lamp can be used as a current limiter. It replaces the circuit breaker of Fig. 5-9 and is wired in the same way. Current passes through both filaments in series.

so that it won't trip-off when operating your largest locomotives. For small-gauge railroads 3 a. will be about right. The circuit breaker has only two connections and you put it in the + wire coming from the power pack, Fig. 5-9.

Some fellows use a No. 1000 (32-32 candle power) automobile headlight bulb in place of the circuit breaker. Wire it so that the current has to flow through both filaments in series, Fig. 5-10. When cold, the bulb has little effect on train operation (less than ½-ohm of resistance). But if you have a short circuit, the bulb lights up and, since the filament becomes very hot, its resistance increases about sixfold. Now the bulb will limit the current to about 3 a. This is a "current limiter" and has the advantages over a circuit breaker of low cost, automatic resetting, and visible indication. The protection is not as complete, however, so don't let a short circuit light the bulb for more than 10 or 20 seconds before correcting any trouble. For O gauge use two bulbs in parallel.

Meters

A good many fellows like to have an ammeter on the control panel to help in running trains and also as a help in diagnosing trouble (see chapter 15). Fig. 5-11 shows how to connect it and also shows how a voltmeter can be added. The voltmeter has one advantage over the ammeter because its readings will be more nearly the same for a given speed whether you run one motor or several.

The proper size meter should be about 5 a. or 15 v. Most meters can stand up to three times their scale values without being damaged.

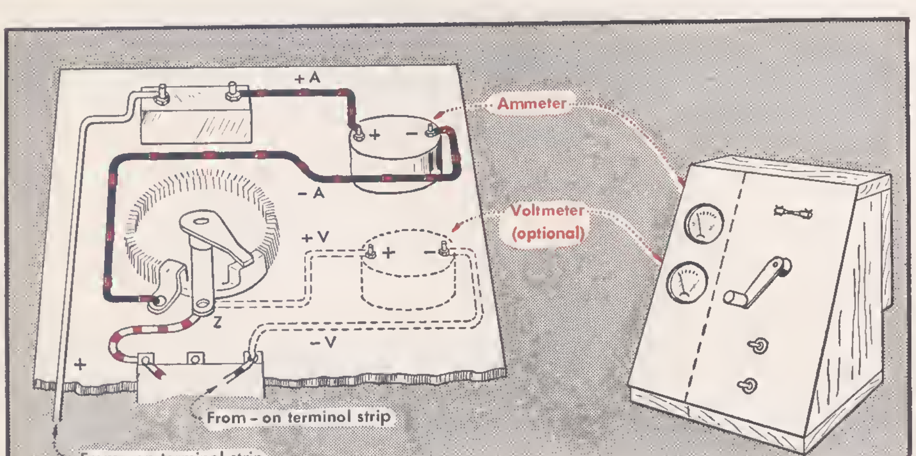
Meters are made with center-zero scales, but these are not necessary if you use the schemes in Fig. 5-11. The center-zero meter suffers because the useful scales are only half as long. It has the advantage of showing whether an engine will go east or west, but your direction controller toggle will show that, too.

The hotshot button

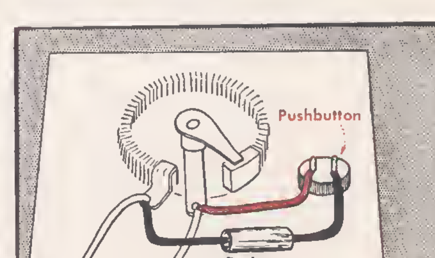
One aggravating thing about some model locomotives is the way they start. You pull back the throttle wondering just when the engine will begin to move. When the engine does start, it lunges ahead and you have to shove the throttle back to keep it from racing.

You can get much better starting performance from many engines by starting them with half-wave D. C. instead of the smoother full-wave power that comes from an ordinary power pack. The idea is to use power that comes in quick frequent jerks. This makes the motor vibrate very slightly, just enough to free it for an easy start. I'll show how in chapter 17.

An older method of improving performance is to provide a way to send one short pulse to the motor to free it for the start. The easiest way is to install a "hot-shot" button on your



5 - 11 If you wish to add meters to your controller unit, build the control box about 3" wider or put the instruments in a separate box with a plug-in connector. Notice the ammeter is in series with the circuit breaker and rheostat, and that the minus terminal of this meter must be the one that is connected to the rheostat. The minus terminal of the voltmeter connects to the minus terminal on the main terminal strip, but you can make this connection at one of the direction controller toggles for convenience.



5 - 12 You can use an ordinary doorbell pushbutton for this hotshot device. Just connect it in parallel with the rheostat.

controller unit panel, Fig. 5-12. To start an engine you set the throttle at the point where you know from experience that the train can barely crawl when it does get moving. Then you touch the hotshot button quickly. With some practice and plenty of patience you can start the train perfectly.

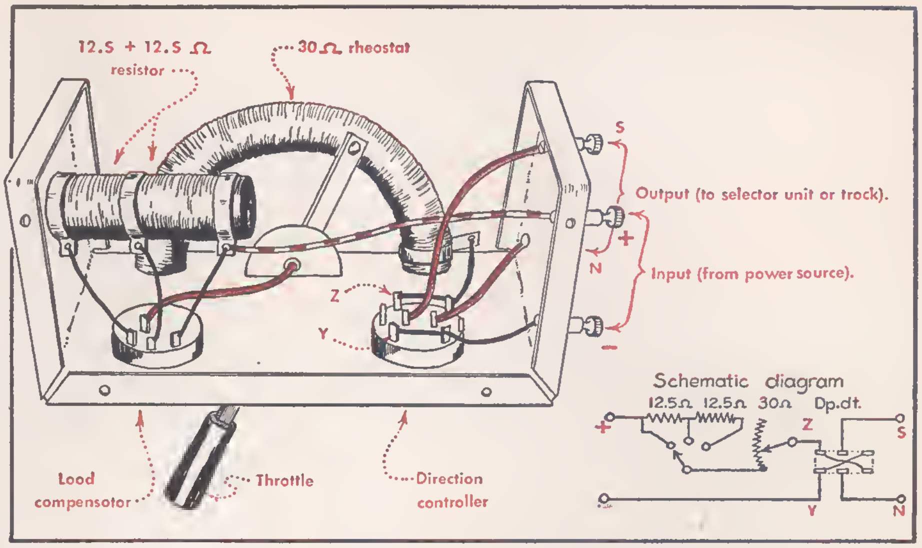
The resistor prevents full pressure from reaching the idle motor when you push the button. This surge *could* weaken the magnet in the motor but certainly would make control difficult. Use a 10 w. fixed (or adjustable) resistor of about twice the number of ohms as your rheostat. This value isn't critical, but you can vary it for optimum results.

Automatic hotshots can be designed using lamp bulbs, relays, capacitors, or vacuum tubes, but these are too specialized to review here.

Throttle improvements

A rheostat has some limitations as a speed controller, but these can be eliminated by fairly simple means. The biggest limitation is that it does not handle a small load and a big one with equal facility. If your rheostat has enough ohms to be able to stop a light engine smoothly, you may have to turn it quite far to get a heavy train started. Marnold overcomes this with a clever scheme in his throttle-like controller units. He adds a three-position "load compensator" toggle to the rheostat circuit. This can cut 12.5 or 25 ohms in series with the 30-ohm rheostat. For heavy loads the throttle gives you a range from 0 to 30 ohms. For very light loads the range is 25 to 55 ohms and the intermediate range is 12.5 to 42.5 ohms, Fig. 5-13. This works on the theory that a light engine will run full speed even with 12.5 or 25 ohms in the circuit. When a heavy load is operated, the load compensator is moved so that only the rheostat is used. If you need an extra direction controller toggle to power a turning track, power it from Z and Y which you can reach by opening the case, Fig. 5-13.

Twister knobs are not very railroad-like so the lever type of throttle is fast gaining popularity. You can buy or else rig up gears or pulleys to operate an ordinary rheostat from a lever, and, if you do the work yourself, why not go all the way and build a cab something like Ed Spinney's on page 9. The mechanical drive for the rheostat can be an arrangement of strong cord and a counterweight.



5-13 This commercially made controller unit has a load compensator to match its 30-ohm rheostat to locomotives that need as high as 55 ohms for slow running. If you want to add a second direction controller for a turning track, add the crossed wires to a center-off dp. dt. toggle as in Fig. 5-3 and then connect **1A** to **Z** and **1** to **Y**. The output to the turning track will be from **0** and **0A** of the new toggle. You can mount the toggle in the space between load compensator and the original direction controller by drilling a ½" hole.

In Fig. 5-14 I have shown how the controller parts are related to the rest of the railroad. On page 20 you'll see how the job looks mechanically.

Summary

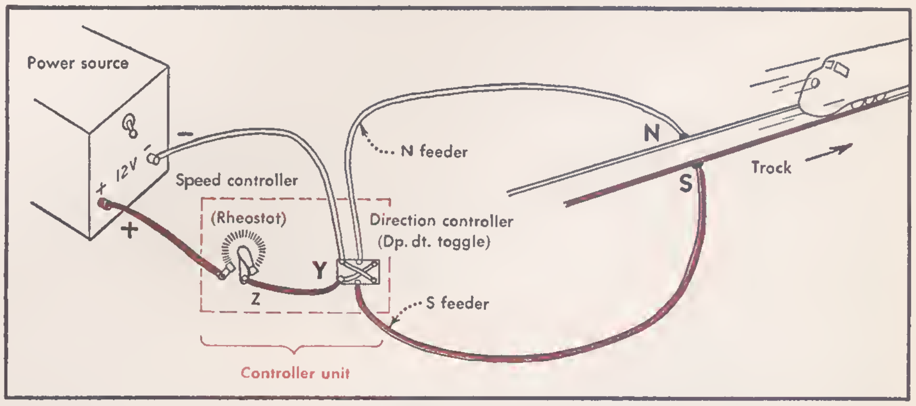
A. Most motors in scale model locomotives will turn the other way when you reverse the flow of current through them.

B. A dp. dt. toggle with crossed wires added makes a simple direction controller (reversing switch).

C. You can substitute any kind of dp. dt. switch or toggle for another as long as it can handle the 3 a. or 5 a. of current.

D. Counterclockwise motion is eastbound.

E. The controller unit is a panel which includes a speed controller, one or two direction controllers, and sometimes other refinements. It is convenient to place it to your left while running trains.



5-14 This shows how the wiring in the controller unit is related to the whole circuit. Compare this complete control circuit with the one we started with on page 3. The two are really exactly the same electrically except that the direction controller allows you to twist the polarity of the feeders at the right to get westbound as well as eastbound operation. Wiring for several trains may look complicated, but it is merely repetitions of parts of this foundation circuit.

Wire

YOU can use hundreds of different kinds of wire for feeders, and chances are your hobby dealer will have a variety quite suitable for the various needs on your railroad.

Feeder wire should be insulated because there is a chance two wires might touch sometime. Insulation prevents what is called a "short circuit." For the moment suppose the feeders in Fig. 6-1 are bare copper, no insulation, and that they happen to touch.

Now electricity has a choice of two paths, one around the usual route and another taking a short cut at the point where the wires accidentally touch.

But the short path has much less resistance in it than the long one — a hundredth part of an ohm perhaps. This means much more of the electric current is going to take the "short circuit" path. The amount of current that is left to pass through the locomotive is too weak to turn the motor.

Short circuits are a cause of perhaps a quarter of the troubles in wiring, so be sure to use prevention to guard against them, instead of cure to repair the damage.

The insulation on wire for feeders can be scanty as long as it isn't going to get much wear and as long as it completely covers the wire.

Radio hookup wire is easy to get in most cities and is well insulated and easy to use. The kind of wire used to wire houses is excellent but very hard to use. If you want to use house wire, keep the number of bends to a minimum and solder short pieces of hookup wire at the ends wherever you want to connect to the track or a control element. The small wire will be easier to manage.

Lamp cord wire can also be used but it takes considerable time to remove the rubber insulation for a connection unless you buy a small tool just made for the purpose.

Bell wire is good, but paper covered wire doesn't stand up well.

Wire is made solid and also in a more flexible form called "stranded." Stranded wire is much easier to use and is usually worth the slight extra cost. It may seem difficult to use if you try to make solderless connections because the ends tend to fray. A soldered connection is much safer, anyway, and minimizes fraying.

Wire sizes

The important thing about wire is its size. Size 14 is popular for feeders to track and other long runs. Size 18 is smaller, but there are many places where it works out better than a larger wire. Connections inside control panels, short track feeders, and temporary connections fall into this class.

The table of wire sizes on page 20 shows sizes in common use.

The list of safe current for copper wire has two columns. These are a guide to prevent damage from heat. Naturally, since wire has resistance, some heat will be generated whenever electricity passes through. The table shows how much current you can push through a wire without raising its temperature more than 55° Fahrenheit. The figures are based upon the use of a thin covering of plastic such as that used on radio hookup wire. If the covering is thick or if it is rubber (now rare), reduce the current to about half that shown in the table.

If the wire is in free air, use the fifth column of the table. If it is in a cable of several wires or inside a control panel or other closed space, use the sixth column.

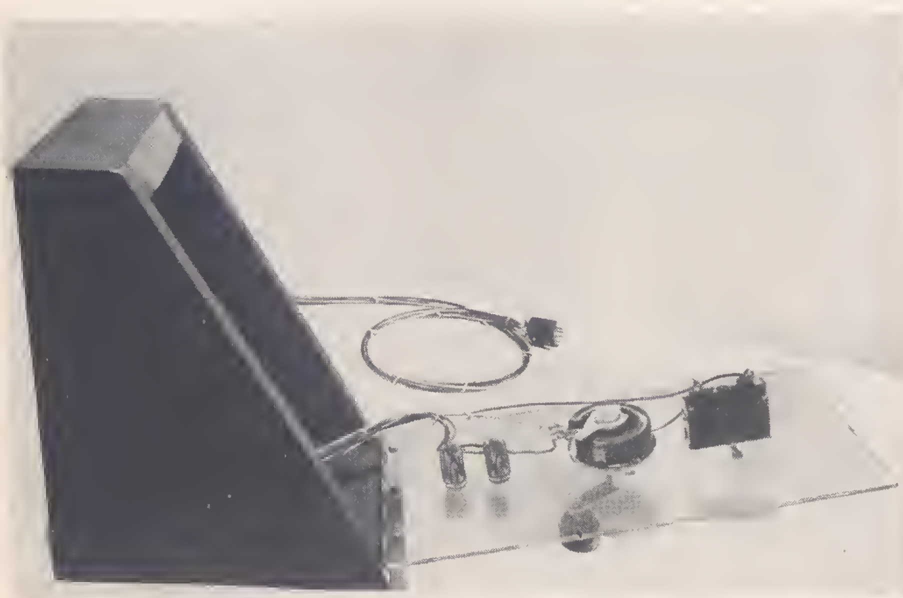
The seventh column shows the resistance of nichrome wire in the same sizes. Nichrome is used in rheostats, heaters, and other resistance devices.

Cables and terminals

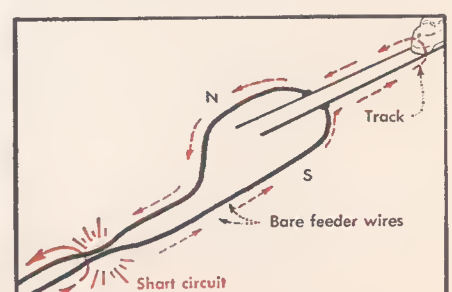
Instead of running wires from the track directly into control panels, terminal strips should be used. These keep wires organized and make it easier to find troubles if you should get a short circuit or an open circuit sometime. The terminal strip should be considered a part of the control panel even though it is installed outside. If you have many track and other feeders, use two or more terminal strips mounted side by side as in Fig. 6-3.

The advantage of this is that you can remove the control panel with its cable and terminal strip for repairs or improvements without disturbing the difficult part of any of the wiring. Just cut the short jumper wires between strips. Then, when you are ready to replace the panel with its strip, new jumpers are added and you don't have to hunt around to see which wire goes to which terminal.

Screw type terminal strips are best



This is how your finished controller unit might look. I built this one with a plastic panel for demonstration to model railroad "clinic" groups. The Jones plug replaces a terminal strip and makes it easy to use the unit both at home and at the club. This panel has a circuit breaker.



6-1 Short circuit caused by bare wires.

Soldering Check Chart

Solder looks rough, frosty. The work was moved before the solder froze. Re-heat and try again. A wood spring-type clothespin can hold the work for you.

Solder looks blistery with small areas where solder did not flow. The work is not clean; probably grease or corrosion coats the metal surface. Scrape clean or wash with cleaning fluid.

Solder is a big blob. Remove most of it with tip of iron. Wipe iron tip with waste rag to remove excess solder.

Solder breaks off from work when cold. Metal wasn't clean or else you used wrong flux. Use rosin core for all electrical work and for brass, tin, etc. Use acid flux only for soldering steel or iron, then remove all residual flux.

Solder looks like "Spanish plaster." Waves in an otherwise smooth surface. Your iron wasn't hot enough or is undersize for the work. Use a larger iron or a torch.

Solder is smooth and shiny and follows the contours of the joint closely. You have a good joint and have mastered the technique. If you made the joint mechanically and electrically secure before soldering it should last for years.

for semi-permanent work because you can remove several wires and replace them often. You may find it necessary to solder lugs to the ends of the wires so they slip under the screws easily, Fig. 6-4.

You will save time in permanent work by using a simpler type of terminal strip which has pins or loops for each terminal. You just solder the feeder directly to the loop or pin after making a good mechanical connection, Fig. 6-6.

Commercially made terminals are made in lengths from two to more than 20 terminals per strip and the cost is low.

If you find the terminals too close together for convenience, use a strip with many more terminals than you need and wire to every other one. In all cases it is wise to have spare terminals for future needs.

You can make your own terminal strips with brass machine screws and nuts. There is no appreciable saving when you figure costs and effort, but your hobby dealer may not stock terminal strips or you may want a special arrangement of the terminals. A spacing of 1" in staggered rows is economical, Fig. 6-5.

Always provide for some way to label all terminals or the wires which lead to them.

How to solder wire

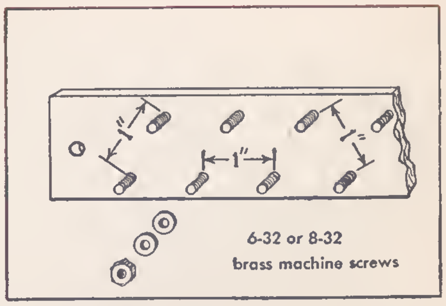
Soldering wire and rail is about the easiest kind of soldering you can do. Even if you have shunned soldering before, here is a place where you can master it and profit accordingly.

Get a medium-sized electric soldering iron, say 100 w. Any smaller size would not heat rail for a feeder connection. Fashion a holder from stiff wire so you can rest the iron without burning your workbench or railroad framework.

Use only rosin core solder of top quality such as Kester's or Multicore. Never use acid core or "non-corrosive" flux on wiring. These both contain zinc chloride and in a matter of several years the chemical will eat right through some of your carefully made connections.

When the iron is hot, its working tip should be wet with silvery solder. If the tip is partly black, file off the copper oxide and touch solder to the fresh surface. This is called "tinning the iron."

Solder is supposed to make a good electrical connection for you, but it isn't able to stand vibration too well. For this reason wires should be wrapped around terminals for a mechanical joint before you add the solder, as in Fig. 6-6.



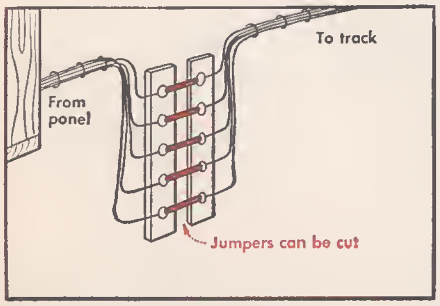
6-5 Small brass machine screws make good homemade terminal strips. This spacing gives room to work, yet takes a minimum of space because of the three-way stagger. You can solder to the screws or use terminal lugs as in Fig. 6-4.

If the wire or terminal doesn't take the solder readily, it may be that it is covered with grease or an oxide. Scrape the surface until it shines and everything should be fine.

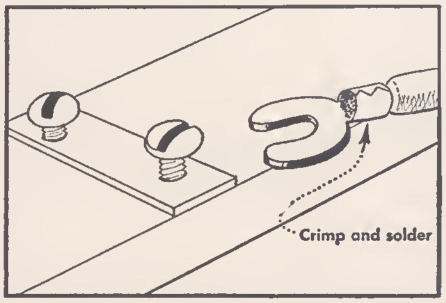
After the solder flows over your connection, remove the iron, but do not wiggle the wires until the solder freezes. Now you have the best possible electrical joint and you should have no trouble later on.

Track feeders

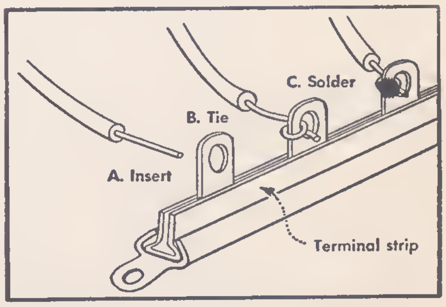
Soldering a feeder to brass rail is about the same except that it takes more time for the iron to heat the rail



6-3 Two terminal strips are better.



6-4 Lugs work best with screws.



6-6 How to fasten wire to loops.

Wire Sizes and Characteristics

Wire size AWG	Diameter Inches	Copper Ohms per 100 ft. 68°F	Copper Feet per Ohm	Copper Safe current in amperes In free air	In closed space	Nichrome Ohms per Foot
12	0.080	0.16	625	30	15	0.092
14	0.064	0.25	400	25	13	0.146
16	0.051	0.40	250	20	10	0.233
18	0.040	0.64	156	15	8	0.370
20	0.032	1.02	98	10	5	0.589
22	0.025	1.61	62.4	8	4	0.936
24	0.020	2.57	39.9	5	3	1.49
26	0.016	4.08	24.9	4	2	2.37
28	0.013	6.49	15.5	3	1.5	3.76
30	0.010	10.3	9.7	2.5	1.3	5.98
32	0.008	16.4	6.20			9.52
34	0.006	26.1	3.98			15.1
36	0.005	41.5	2.48			24.1
38	0.004	66.0	1.52			38.3
40	0.003	104.9	0.96			60.8

AWG wire sizes 22 20 18 16 14 12

before the solder will wet it. Hold the iron on the joint between wire and rail and apply the solder to the rail just above the connection as soon as the rail is hot. The solder should creep along the rail a bit and the whole connection should look wet. If you have any trouble with any kind of soldering use the check chart on page 19.

Steel rail requires more care and may not make a good joint with the rosin core solder. The trick is to do the job in two steps.

First scrape the steel clean until it shines at the place where you want a connection. Then apply liquid soldering flux ("acid-flux") with a damp cotton swab. Don't let the flux touch the roadbed, and don't apply so much that it sizzles when the rail is hot.

Now coat the rail with a wet layer of solid solder (no core). When the coating is frozen, wipe the rail to remove all traces of the chemical with a rag or swab that has been dampened with clean water.

Step two is the same as though the rail were made of brass. Use rosin core solder this time.

In the next chapter I'll give you a few more pointers about feeder connections.

Summary

A. When an accidental path for electric current by-passes the intended path, you have a "short circuit."

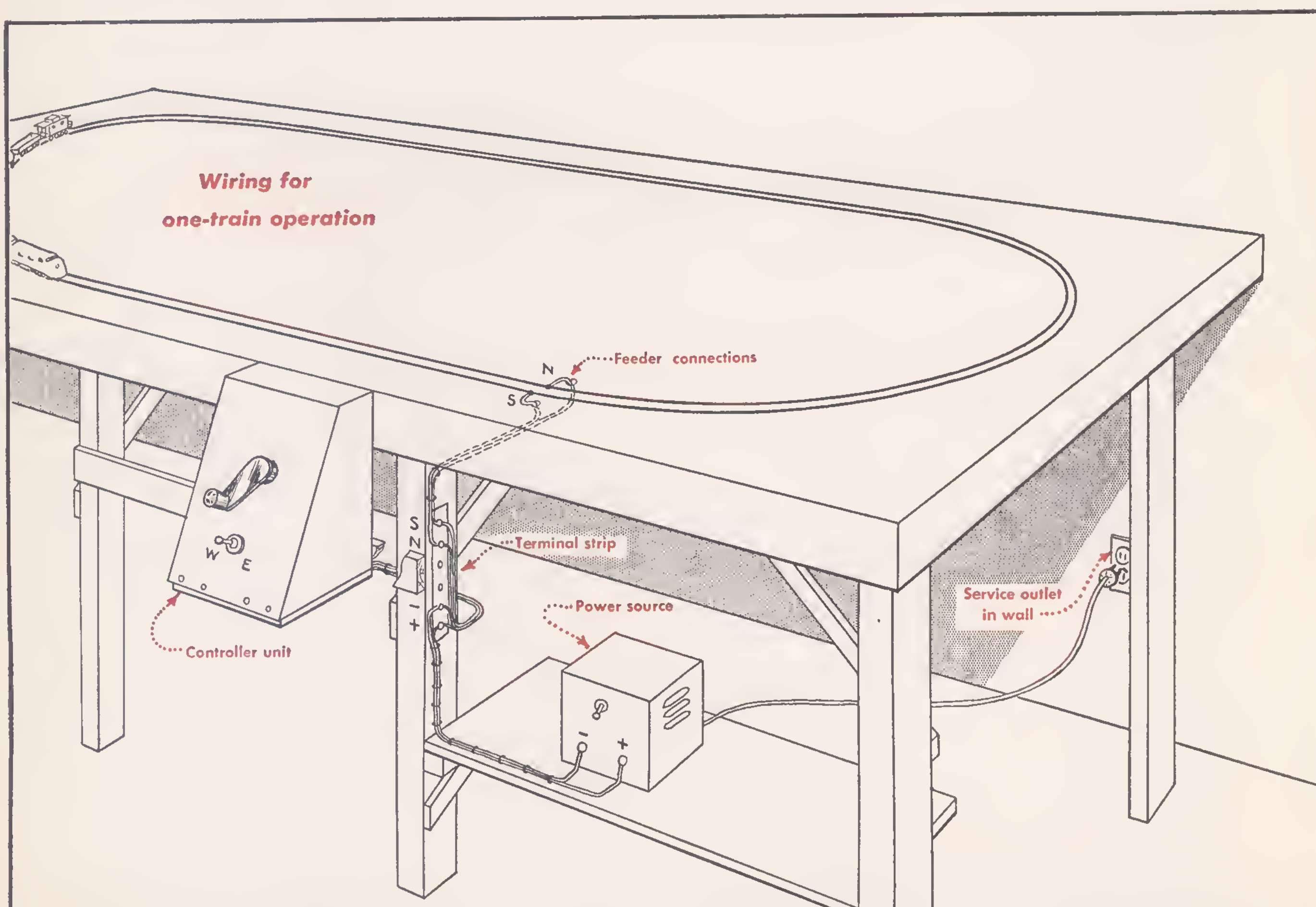
B. A short circuit robs most of the power from other parts of the circuit and may be a fire hazard.

C. Stranded wire is easiest to use in all larger sizes.

D. Soldered connections are best.

E. The use of terminal strips is the best way to make connections.

F. Use only rosin core solder for wire connections.



6-7 Your control connections will look something like this when you finish your installation. If you have turnouts there may be more track feeders.

Track Wiring

YOUR track pattern is different from most other model railroaders' systems, and this is the one place where each fellow must do things differently. Fortunately, you can wire your railroad perfectly by following a few easily understood pointers. Your problem will be one of choosing the best places to attach feeder wires, where to locate the control panel or panels, and where to break the rails so electricity doesn't get into parts of the track where you don't want it.

Let's get the control center located first. Naturally, it must be in a place where you can sit or stand to operate the railroad. It should be in a place where you can see most or all of the railroad, preferably without turning around.

The center should also be near the most concentrated part of your trackwork so you are within easy reach of derailed cars and other troubles that may develop in the early stages of the work.

When you find a suitable place, mark it on your big track drawing. Indicate whether you will face the railroad at that point, or sit sideways or perhaps diagonally to the track.

Your feeder wires will run from the control center to your track, preferably by a short route. Sometimes only a single pair of feeders is needed, but you may have a track pattern that requires two or more pairs. Later, when you are ready to run two or more trains, you'll definitely need more than two feeders.

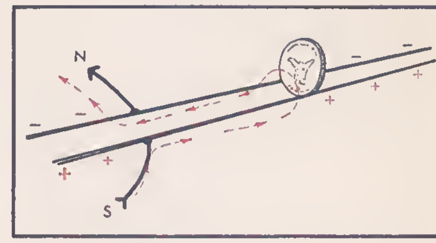
In the following chapters I'm going to give you the practical steps to take in planning your track wiring, and then I'm going to explain why you must do some of these things. The explanations may seem unimportant at first and you may skip over them if you wish. They may be very helpful later on if you have to hunt for the source of some trouble.

Wiring simple track

A simple track with no turnouts is wired with only two feeders, Fig. 7-1. If the distance to either end from the feeding point is not too long, this is all the wiring you will need.

Let's see what happens in our simple track when we turn power on. Even without a locomotive, electric pressure extends through the track in both directions from the feeding point, Fig. 7-2. The pressure tries to force electrons from one rail over to the other.

Suppose we bridge the rails of our



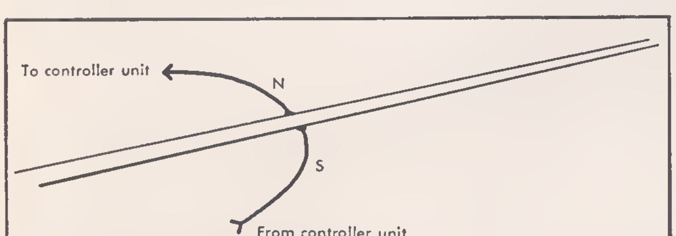
7-3 Pressure extends to the end of the track in both directions along both rails, but current flows only where a complete path is available. There will still be an electrical pressure between the rails, but the pressure will be considerably less than when no current flows. Perhaps 1 v. instead of 12 v. or more.

simple track with a metallic object. Perhaps a jokester places a coin across the rails, Fig. 7-3. No matter how far down the track our "friend" commits this crime, current will flow through the coin because the pressure between the rails extends all the way to the end of the track in both directions.

A locomotive on the track is really the same as the coin except that it has more resistance and it does something useful. Since the pressure extends through the entire length of the track, the engine can run from one end to the other and always be sure of its power supply.

You can put two locomotives on the track and both will run. This is because the pressure reaches each of them and thus current flows through both (look back at Fig. 2-3, page 4). This makes it possible to run doubleheaders and pushers on your railroad.

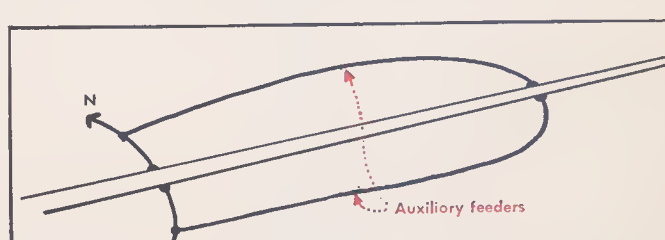
Note the difference between the pressure across the track without and



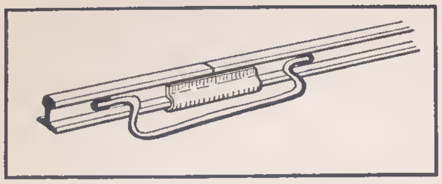
7-1 The simplest track wiring occurs when you have no turnouts. The rails are merely continuations of the feeders.

7-4 When a train operates far from the feeders, any poor rail joints will waste power that should reach the loco.

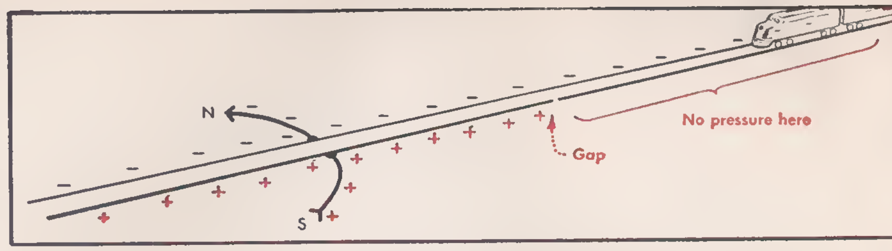
7-2 Positive and negative pressure extend to the end of the track in each direction from the feeders. The pressure difference would like to push electric current from one rail over to the other but cannot do this unless there is a metallic path.



7-5 Auxiliary feeders provide an extra path for electricity to reach trains. This not only helps to overcome the effects of bad rail joints but by-passes some of the resistance of the rails as well. In chapter 12 I'll tell you more about auxiliary feeders.



7 - 6 This rail bond is made of copper wire soldered to rail ends each side of a joint. The bends are necessary to allow for temperature expansion.



7 - 7 The gap in the south rail prevents electricity from flowing to the far end of the track.

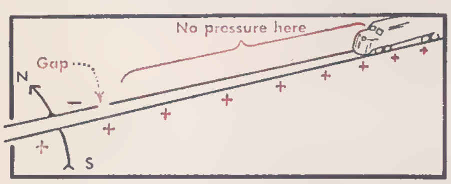
with a "load." In Fig. 7-2, where there is no load, the pressure between rails at all points is 12 v. or more, the same as at the power source. *This is true even though the throttle might be in a "slow" position.*

But when you have a load, the pressure is wasted all along the path of current. Thus the load will never get all of the pressure available at the power source.

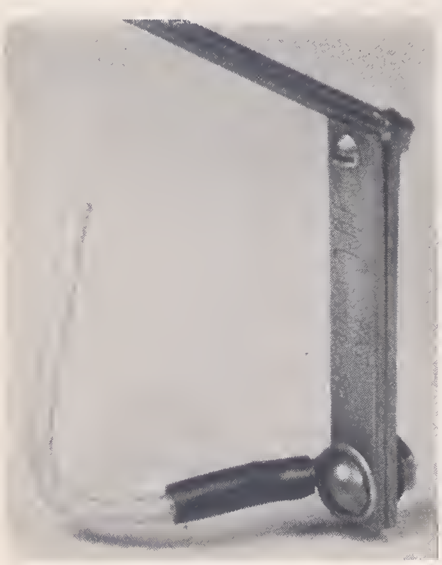
The pressure between rails or any other two points depends upon how much of the total resistance of the circuit lies between the points.

If the coin in Fig. 7-3 has a resistance of 0.1 ohm, and the rest of the circuit, including power source, has a total resistance of 0.9 ohms, the pressure between rails would then be a tenth of the no-load source pressure.

This makes it important to waste as little pressure as possible in the feeders and track, at least for full-



7 - 8 This is the same as 7-7 except that the gap is now in the north rail. In either case electricity reaches only one of the two rails, so no train can move in the far part of the track.



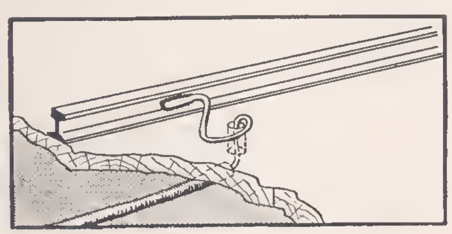
This rail clamp (the HI-C make) attaches to the rail from underneath.

speed running. See what happens when there is a defective rail joint between the feeders and the locomotive, Fig. 7-4.

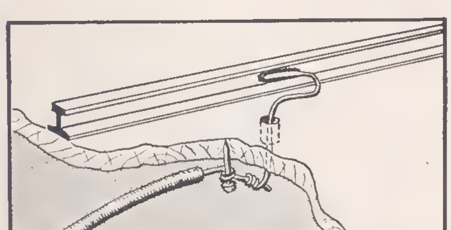
When the metal parts of a rail joint do not make a firm contact, electric current will have a tough time passing through. The high resistance of the bad joint wastes power by producing heat. It also causes a loss in electrical pressure available to the locomotive.

Sometimes only one or two rail joints misbehave, but more often each rail joint wastes a little power. The waste at any joint may be too little to bother with, but when the train gets far from the feeders the current passes through so many joints that much power is wasted. The train cannot even run at its full speed.

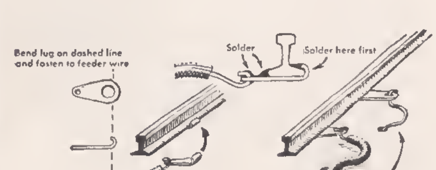
When this happens you can do one of two things. You can add "auxiliary" feeders to carry electric current and pressure to the far end of the track, Fig. 7-5, or you can add "bonds" to the rail joints as in Fig. 7-6. Notice that in either case all you really have done is to provide a better path for the electricity to reach the track ends.



7 - 9 Feeder connection with flexibility.



7 - 10 This feeder connection is better.



7 - 11 Sometimes lugs help make connections.

The bond method is safer because you are not likely to make any mistakes when you use it. The auxiliary feeder is less time consuming and may do a better job, but you must be careful that the auxiliary feeders are connected to the proper rails. When you have turnouts and crossings, this may require some care. I'll tell you about auxiliary feeders in more detail in chapter 12.

Sometimes you won't want electricity to go all the way to the end of the track. Then you can make a break or "gap" in either rail, Fig. 7-7.

A gap is made by omitting a fish plate or by cutting through the rail with a fine-toothed saw or motor tool. Then you squirt a little model cement into the break to keep the rail ends from creeping toward each other during hot weather next year.

If your track is not yet laid, you can use a plastic fishplate in place of the usual metal one to make a gap. The plastic fishplate has a little separator built in that prevents the rail ends from touching.

Notice that it doesn't matter which rail you put the gap in, Fig. 7-7 and Fig. 7-8. In either case pressure reaches a locomotive through only one of the rails — thus, because of the gap, the current cannot flow. Later on we'll find some reasons for putting gaps in one rail or the other or sometimes both rails.

Feeder connections

If you plan your wiring before you lay track, you can install metal clamps to make good out-of-sight connections. These solderless clamps require a hole through the sub-base and roadbed directly under the rail. You fasten the clamp to the rail before spiking, and then fasten the feeder wire later with a screwdriver.

Many model railroaders lay track first and then use a clip on the order of the connector clip used on toy railroads, or solder the connection as we did on page 18.

When cold weather comes, feeder wires will contract and exert a strong pull, strong enough to pull rail out of gauge or even to break a connection. Vibration can also break a connection, so it is best to leave an S-shaped slack curve in the last inch of feeder before

it reaches the rail connection, Fig. 7-9.

An even better scheme is to use a brass brad or machine screw as a terminal as shown in Fig. 7-10. As a variation of this, the brad can be driven all the way through the roadbed. Then you solder the feeder to the underside, and a number 18 wire between the upper side and the track. This wire needs no insulation and thus is less noticeable.

When you use large number 14 or 12 feeder wire, the wire is too heavy to solder directly to the rail and a scheme such as this is a big help.

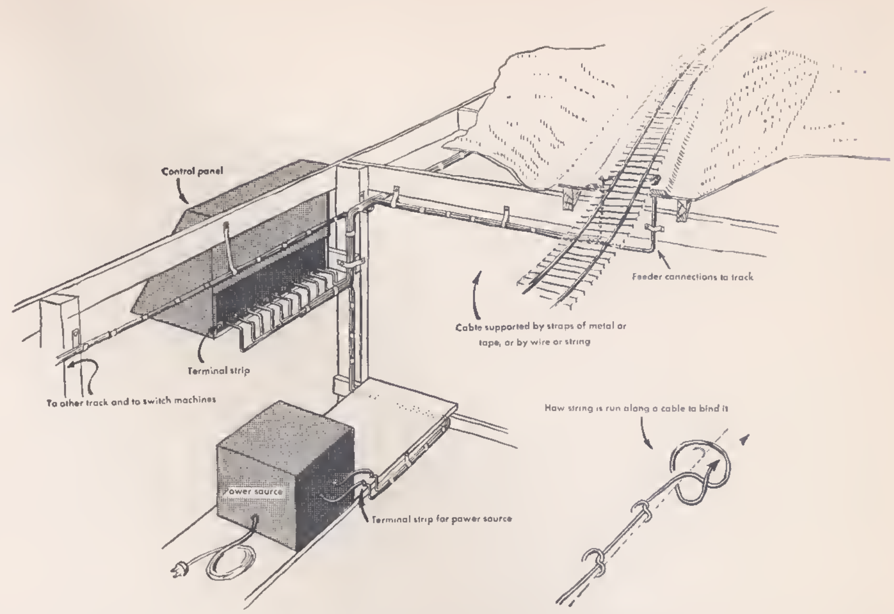
Some folks use a radio lug to make the connection, Fig. 7-11.

In the next chapter I'll show you more about track wiring, and to save space we're going to use some schematic diagrams instead of the pictorials. Schematics are easier for you to use because the symbol for a gap doesn't require any erasure. If you draw the track with a line for each rail, a bar across a rail represents a gap. Fig. 7-12 is exactly the same as Fig. 7-7 except that it is schematic.

If you draw track with only one line to represent both rails, the bar would indicate gaps in both rails, Fig. 7-13. When you want to show a gap in only one rail, use half a bar. Fig. 7-14 is the same as Fig. 7-7 and Fig. 7-12.

Bar symbols to represent gaps are a very old custom in railroad wiring and many track plans in the Model Railroader magazine and in books on model railroading use these same symbols to show where to put gaps and feeders.

Occasionally you will also find a gap indicated by two short lines and a break in the line representing a rail. This requires erasure and is not in as widespread use, but there are some model railroaders who still use it.



7-15 This sketch shows how feeders can be grouped and run to the track at various parts of your railroad. Wires to control turnouts can be included in the same "harness." This control panel includes its own terminal strip. Usually it is better to have the strip separate as in Fig. 6-7 to make installation and maintenance easier.

Summary

A. Locate your control center for convenience in handling trains.

B. Electric pressure extends as far down a rail as good connections will permit. It extends in both directions from the feeding point.

C. Electric pressure difference between rails tries to force current from one rail over to the other.

D. Current will flow through any metallic object that bridges the distance from one rail to the other.

E. Current cannot flow well through a poor rail joint.

F. Bonds and auxiliary feeders improve distribution through long sections of track.

G. Breaks called gaps are used to stop the flow of current to parts of the track where it isn't wanted.

H. Model cement is squirted into a gap to prevent rail ends from touching.

I. Feeders should be connected firmly to the rail with clamps or solder.

J. Don't connect large wire directly to a rail.

7-12 When a separate line is drawn to represent each rail, figure 7-7 would look like this in schematic form.

7-13 This is the symbol for a gap in both rails when only one line is drawn to represent both rails of a track.

7-14 In one-line schematics, this is how a gap in only one rail is shown. This one happens to be in the south rail.

Turnouts Make a Difference

If YOU add one or more turnouts to our simple track, lots of interesting things can happen to the electric control circuit. Look at Fig. 8-1 for example. I have put the letter *S* at the place where the power feeder connects to the south rail of the track and *N* beside the north rail where the return feeder taps it. I also placed a row of smaller *S*'s all along the south rail to show how far the electric pressure from the south feeder extends. Notice that they not only run down the curved branch of the track, but also reach the far end of the main track by passing right along the metal points of the turnout. The *N*'s from the *N* feeder have a much simpler path — the same they would follow with no turnout in the track.

If you run a locomotive along the main line, it will run all the way because there is a difference in electric pressure across the two rails all the way.

But if you put the engine on the branch track, both rails there are connected to the *S* feeder only. Since there's no voltage difference across the rails, the engine will not operate.

If you throw the points of the turnout, they will then touch the north rail instead of the south. The points act just like a toggle switch and now the engine can run down the branch but not past the turnout on the main line, Fig. 8-2.

This "automatic power routing" is a wonderful thing if you make it work for you. Notice how your power automatically runs down the main or branch track depending only on which way you throw the turnout.

It is important that the points of the turnout make good contact with the stock rail at whichever side they rest.

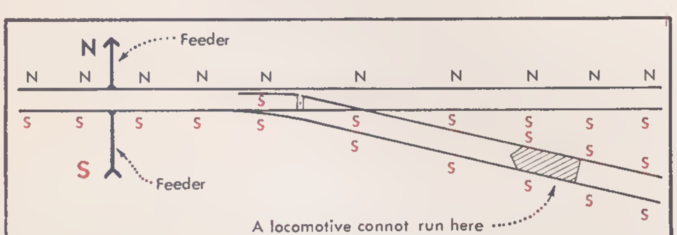
If you are going to hand operate your turnouts, add a short tab of phosphor bronze to the underside of the point rails as in Fig. 8-3. The idea is that the bronze spring should run against the underside of the stock rails and thus make better electrical contact.

If the points are pivoted, you may want to add a pigtail jumper of stranded flexible wire to connect the points with the frog part of the turnout as in Fig. 8-4. Points that merely bend don't require this addition.

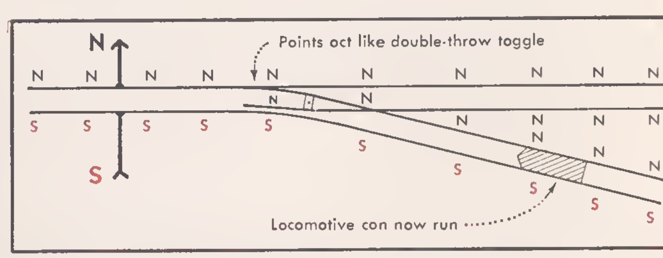
If you plan to operate your turnouts with electric switch machines or some other mechanical means, buy a set of make-break spring contacts and connect them as in Fig. 8-5. This makes the phosphor bronze spring and the pigtail unnecessary and, at the same time, does a better job. The contacts guide the electricity the same way the points do when you throw a turnout, but they do a more dependable job. The springs should be bent so the moving contact breaks away from one side before it makes contact with the other.

You can install these contacts after you have the rest of the wiring done. Usually you can get by without them for a while if the turnout points don't collect too much dirt.

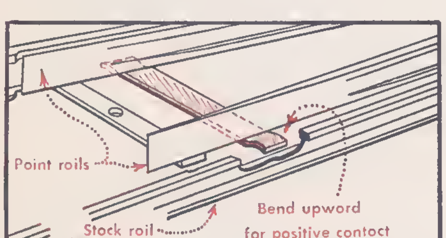
There is one curious thing that may happen to you if a turnout doesn't make a good contact with either stock rail. Here's how it happened once on the Model Railroader's test railroad, Fig. 8-6.



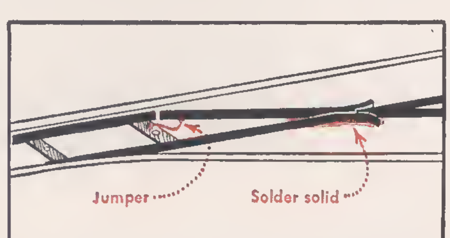
8 - 1 Power from the S feeder passes through the turnout point and continues along the main track. The branch is dead because both rails are connected to the S feeder.



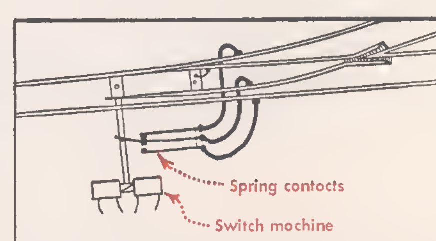
8 - 2 Now the turnout points have moved and both S and N polarity is available along the branch track. The main track is now dead beyond the turnout. This is automatic power routing.



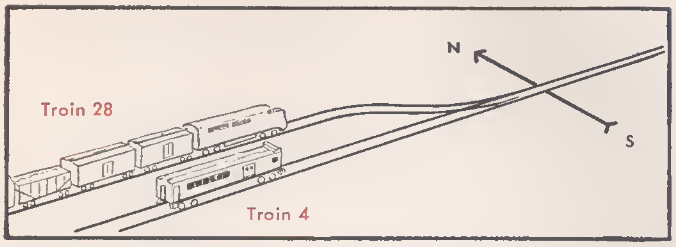
8 - 3 A strip of phosphor bronze added to your turnout points improves operation. The strip should be long enough to rub under the stock rail but not so long that it can ever touch both stock rails at the same time.



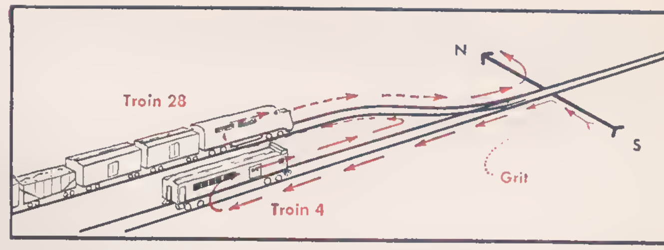
8 - 4 Besides the contacts of Fig. 8-3, or Fig. 8-5, it is a good idea to install a flexible pigtail jumper wire between the points and closure rails. The frog should be made electrically solid by filling with solder below the flangeways.



8 - 5 Spring contacts operated by the turnout throw rod are better than the tabs of Fig. 8-3 but cost more. The central spring moves to touch either contact depending on the way the turnout is operated.



8 - 6 Train 28 stood in the passing track and I wanted to operate train 4. When I applied power, train 4 started but without much pep. When I increased the power, both trains began to crawl toward the single track even though the turnout was alined for the main.



8 - 7 This happened because a small piece of grit prevented the turnout points from making contact. Current followed the solid arrow path as it should, but was also diverted via the dashed arrow path because of the poor connection.

I had two trains standing on the main and passing tracks and thought everything was ready when I pulled the throttle. But instead of a train starting, neither one moved at all.

I pulled the throttle a little more and one train started rather slowly. Then I pulled for more power. Suddenly the second train also started, and both headed for the single track. I released the throttle just in time to avert a paint scraping tussle at the turnout. The villain was, of course, a little grit that had wedged itself between the point and stock rails of the turnout. The resistance of the grit was very high, and so electricity passed through both trains in series, Fig. 8-7.

One train started first because its motor had a higher resistance and thus it received more of the electric pressure than the other. Its load was smaller also.

Automatic power routing

The principle of automatic power routing works just as well with many turnouts as it does with only one. The only limitation is that all of the turnouts point in the same direction. Fig. 8-8 shows a yard lead. Notice that the only track that gets power from the *S* and *N* feeders is the very same track toward which the turnouts are alined.

In Fig. 8-8 you will notice that only two of the rails connect directly to feeders. These can be called the "feeder rails" (heavy weight lines). All other rails get their power through the points of the turnouts and thus might be called "intermediate rails" (light lines). The polarity of intermediate rails will always depend on the way the turnouts are alined.

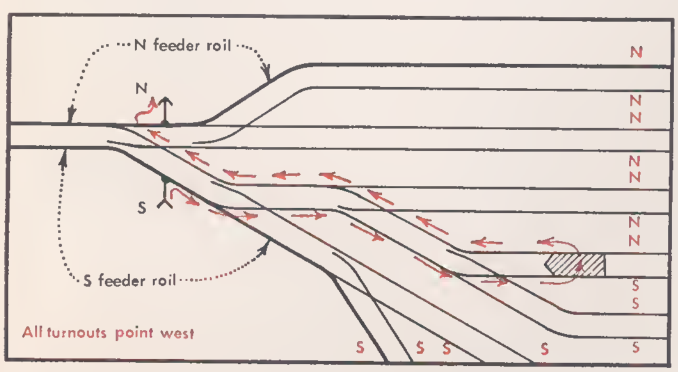
I said before that all turnouts must point in the same direction to insure successful automatic power routing. This isn't strictly true, because you can power two groups of turnouts from the same pair of feeder rails, and all the turnouts in one of the groups will point toward the other group. Fig. 8-9 shows an example of this.

Why must the feeder rails be the outside rails of every group of turnouts, and why must all turnouts in a group point in the same direction? The answer hinges on the bad things that occur when you try to connect a feeder to any rail that leads to the frog of a turnout. When you master this basic situation you have the key to successful track wiring.

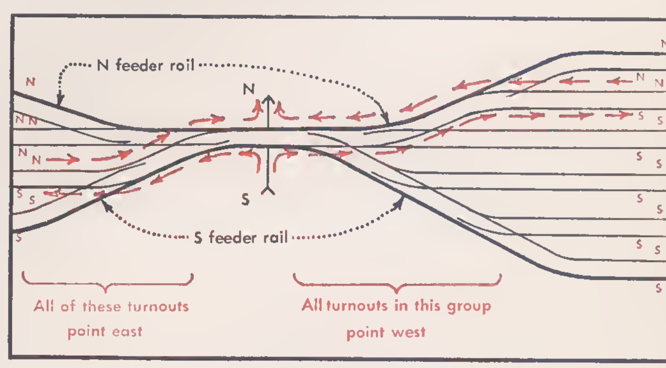
When turnouts point away

Suppose we go back to Fig. 8-1, but this time we locate the feeders behind the turnout. As long as the turnout is set for the main line things are still fine, Fig. 8-10. But when we throw the points for the branch, something awful happens, Fig. 8-11. Now the points, which were so obliging before, have bridged the rails and made a short circuit from the *S* rail and feeder to the *N* side. Trains won't get enough power to run on any part of the track.

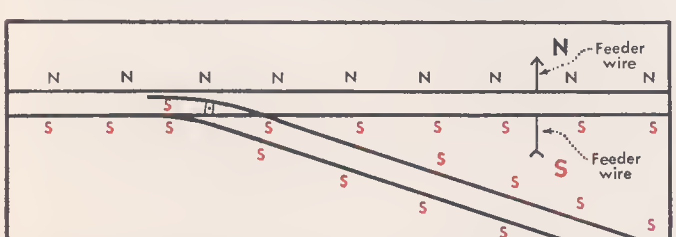
The easiest way to prevent this kind of short circuit is to locate your feeder connections with care. We had trouble with Fig. 8-11 but not with Fig. 8-2. From this experience we set up the first rule of track wiring.



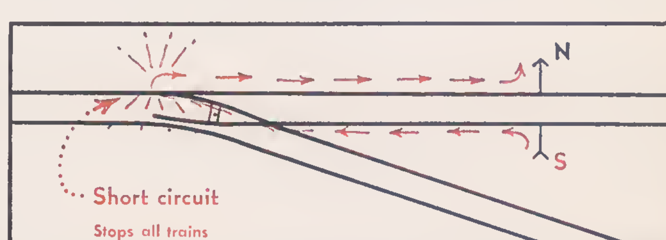
8 - 8 Any of these seven yard tracks can be energized depending on which turnout points touch the outermost "feeder rails."



8 - 9 Two groups can share the same pair of feeder rails All turnouts in each group must point toward the other.



8 - 10 When a feeder wire connects to the rail leading from the frog of any turnout, trouble will result. To prevent the trouble, the feeder must be moved or else a gap placed between the feeder and the frog.



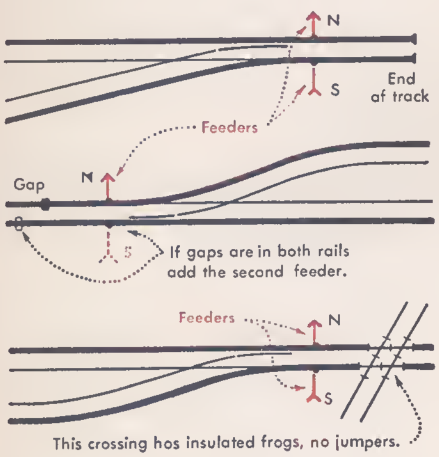
8 - 11 This shows why a feeder behind the frog of a turnout makes trouble. When the turnout points are alined for the other branch, power finds a short-circuit path through the points. This stops all trains.

1. Never locate a feeder on a rail which leads directly to or from the frog of a turnout, Fig. 8-12.

8-12 The rails shown in light weight lines connect to the frog. Do not feed to them.

Rule 1 is basic, but it doesn't tell you where you *can* put feeders. Rules 2, 3, 4, and 5 cover all feeder locations, and rule 2 is based upon rule 1.

2. Locate feeders wherever a turnout points toward a stopper, Fig. 8-13.

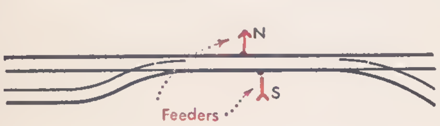


8-13 Here are three examples of turnouts pointing toward gaps, end of track, or insulated frogs. Notice how feeders always connect to the outside rails of a turnout which I've shown heavy. The actual connecting point can be anywhere along these rails as you will see later on in chapter 12.

A stopper is a gap, insulated frog, or the end of track. These are all electrically equivalent and I use the word *stopper* in these rules to include all three kinds.

You don't have any gaps yet, but you may have a track that ends and possibly a crossing with insulated frogs. If jumpers are added, however, the insulated frogs are no longer effective stoppers.

Rule 3 is another variation of rule 1 and on a one-train railroad you'll probably use it more often than rule 2.

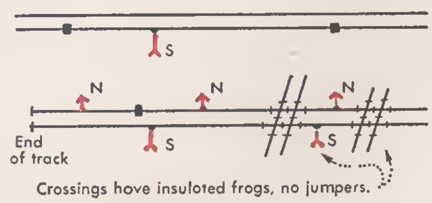


8-14 The feeders are shown in color only for emphasis. You can draw them in with the same color as your track. Turnouts might be far apart and separated by several curves, but the rule still holds if they face each other.

3. Locate feeders wherever two turnouts point toward each other, Fig. 8-14.

The next rule is another that is used more often on multi-train railroads, but you may need it if you have a crossing.

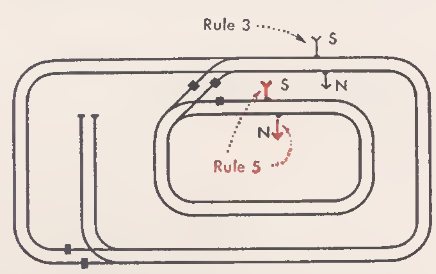
4. Connect a feeder to any rail which runs between two stoppers, Fig. 8-15.



8-15 Here are all possible combinations to which rule 4 applies.

The only thing you might have left that could need feeders would be an oval in which all turnouts point the same way. It doesn't matter where you connect feeders to the oval, so put them nearest to your control center if you can.

5. Connect feeders to any oval of track that does not yet have feeders and then apply rule 6. Fig. 8-16.



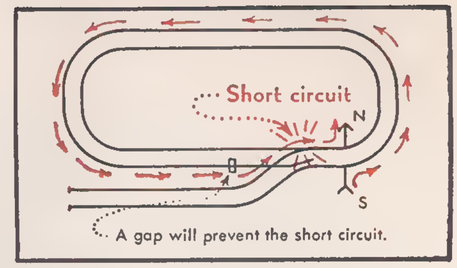
8-16 Other rules didn't provide any feeders for the inner oval, so rule 5 comes to the rescue. Notice how the rule 3 feeders apply even though the turnouts point toward each other around two curves of the outer oval. Notice also how the **N** feeder is always at the inside of each oval when one oval is inside another.

Rule 6 will follow shortly.

Now you are ready to mark the tentative feeder locations on your track drawing. There is no need to draw the feeder wires all the way to the control center; that would just make for confusion and if you had to make a change you'd have a long line to erase.

All you do is add a small arrowtail beside the *S* rail (the outer rail of the oval) and a small arrowhead beside the *N* rail at the places the rules indicate. These symbols represent your *S* and *N* feeder connecting points.

These rules are easy to follow when the turnouts and other elements are



8-17 Arrows show the path of current.

close together, but sometimes it's a long way, and perhaps around several curves, between the ends of a track segment, Fig. 8-16. Be sure you check both ends of every segment of your track to see if any rules apply.

The need for gaps

Let's look back at Fig. 8-11 again. Remember how the turnout caused a short circuit and how rule 2 tells us to move the feeders to prevent the short? Well, suppose you can't move the feeders. Suppose you have an oval as in Fig. 8-17 and no matter where you put feeders, they will still be behind the turnout as well as ahead of it. The colored line shows how the path of the short circuit current flows all the way around the railroad to make trouble.

The solution here is to locate a gap in the rail somewhere between the *S* feeder and the frog of the turnout. Now the current can flow only through the train as it should.

Remedies for short circuits when feeders must be behind turnouts can be summed up in two rules that take care of all such troubles.

6. If a feeder must be connected to a rail which also reaches the frog of a turnout, cut a gap in the rail to separate the feeder from the frog, Fig. 8-18.

8-18 This rule is also based on rule 1.

7. When turnouts point away from each other, cut a gap in both rails of the track or tracks that connect them, Fig. 8-19.

8-19 This arrangement occurs often.

This seventh rule also applies to every crossover, and since the con-

necting track in a crossover is so short it is easy to overlook. I usually mark crossover gaps first when I plan track wiring, Fig. 8-20.

I didn't explain why you need rule 7, but it prevents short circuits just as does rule 6. Without gaps, current feeds through one turnout to be short circuited in the next, Fig. 8-21.

Gap location

You may wonder how far from the frog you should cut the gaps. This will depend on how you wish to run your railroad when you get to the two-train stage.

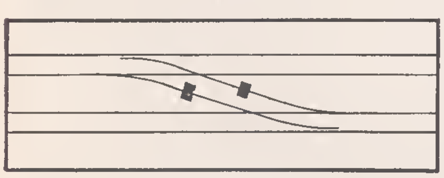
If you feel a train should be operated as in the prototype, with you or a friend always at the controls, then put any gaps the rules call for within the fouling distance of the turnouts, Fig. 8-22. The fouling point is the point at which cars on converging tracks don't quite touch. You can use the point where tracks are 11 scale feet apart.

If, on the other hand, you prefer a crude sort of automatic protection for your trains (at the expense of jerky operation), locate any frog-rail gaps as in Fig. 8-23. The location is different for a right or left branch because of the pickup arrangement in the locomotive.

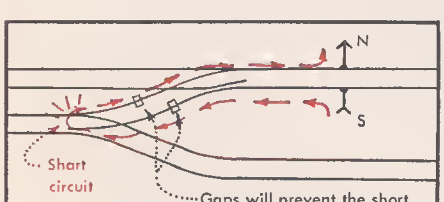
Here is how the automatic protection operates. In Fig. 8-24 your train trundles eastward toward an open trailing turnout.* You are busy with other things and pay no attention to the train. The turnout is opened for the side track, perhaps for another train expected from the east. The position of the points feeds electricity toward the side track but leaves a dead segment on the main line in front of your train.

When the wheels of your locomotive roll into this dead segment, a short circuit occurs. This not only stops the engine very suddenly but also may trip the circuit breaker on the power pack or control panel.

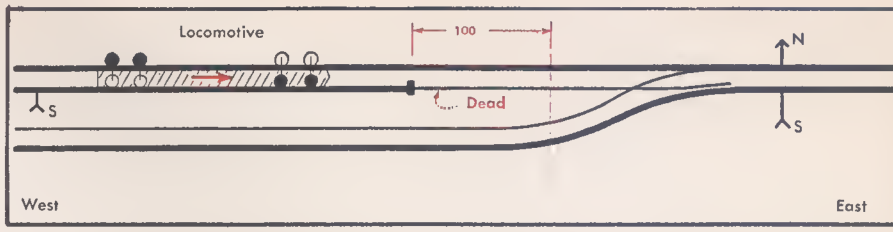
*A "trailing turnout" is one which a train trails through. It points in the direction of traffic flow. The opposite is a "facing turnout."



8 - 20 All crossovers require gaps.



8 - 21 Gaps are needed in both rails of any track where turnouts point in opposite directions. The colored arrows show how a short circuit can occur if the gaps are forgotten.



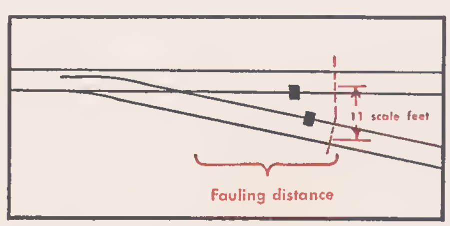
8 - 24 The solid circles represent the wheels that pick up current for the locomotive motor. When the pickup wheels of the leading truck cross the gap into "dead" track, the locomotive stops. The track is dead because the turnout is alined for the other branch.

The advantage of this arrangement is that a solo operator can run a number of trains with a fair degree of safety yet without any special control equipment.

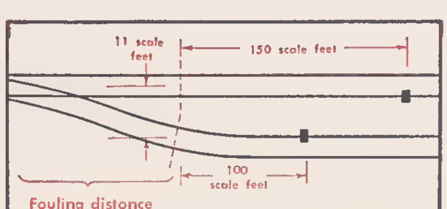
One disadvantage is that when you do want to run in more proper fashion you cannot make smooth stops unless you stop short of the dead segments. This means you'd have to run trains of one or two less cars in length.

A more serious disadvantage is that the wheels of engines and cars are pitted from the short circuits whenever you deliberately or accidentally run into a dead segment of track. At the moment your engine bridges the gap, Fig. 8-24, the full 12 v. (or sometimes greater) pressure is exerted through a short circuit. This will force much more than the normal 1 a. or 2 a. of current through the wheels and overheat them. Metal is actually melted out of the pits that result.

If you want the automatic protection without wheel pitting, add another set of contacts on your turnout throw rods, and wire as shown in Fig. 8-25. Notice this requires extra gaps behind the frog of the turnout.



8 - 22 When rules call for gaps, the best location for them is within the fouling distance of a turnout. This applies to any gaps needed in the outer rails as well as the inner rails. The fouling zone runs from the turnout to the point where the tracks are about 11 scale feet apart.



8 - 23 Sometimes gaps in the frog rails of a turnout are located beyond the fouling zone to give a crude sort of automatic protection. Notice the gap in the left branch should be farther from the frog than the gap in the right branch.

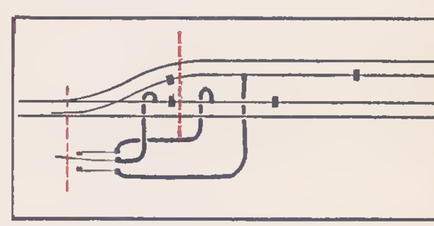
When you apply rule 7, you often have a choice of locating the gaps near one turnout or the other, Fig. 8-26.

Electrically, your decision will make no difference, but it will affect the way you control trains. Suppose you put the gaps near turnout 1W in Fig. 8-26. Then, since power is fed from each end through the two turnouts, the control of the track between turnouts will depend on whether turnout 2W is normal or reversed. ("Normal" is a railroad term indicating the usual position; "reverse" is, of course, the opposite. At a turnout the normal position is almost always the one favoring the more important route.)

The best way to analyze the location of the gaps is to figure from which way the trains will come most often. The gaps should usually be nearest the last turnout crossed. If you get to two-train operation, there may be more things to consider in placing these gaps.

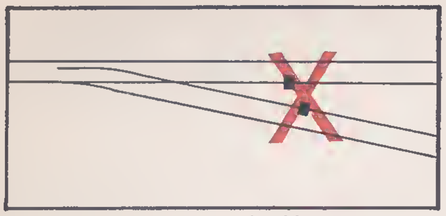
Unneeded gaps

Some model railroaders have the mistaken idea that you should put

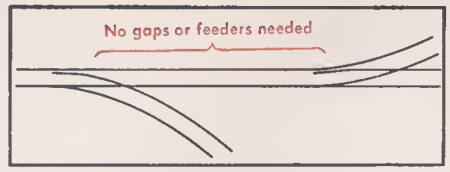


8 - 25 You can get automatic turnout protection without any short circuits through the wheels if you add two gaps and a make-break spring contact. This contact is in addition to any contact you may have for other purposes such as in Fig. 8-5. The more distant gaps should be spaced the same as in Fig. 8-23.

8 - 26 When you have a choice of two turnouts locate the rule 7 gaps toward the far turnout in direction of greatest traffic.



8 - 27 The idea that one should put some gaps behind the frog of every turnout is widespread but falacious. You need gaps here only if called for by the rules.



8 - 28 When two turnouts point in the same direction, on one-train railroads, no gaps or feeders are required between them.

gaps in each rail behind the frog of every turnout as in Fig. 8-27. This idea is so well entrenched that it even gets into print from time to time. I'll admit that the correct rules for track wiring will often bring the same results, but there are just as many more times when the incorrect use of gaps just makes a lot of unnecessary work.

It may be helpful to know that some parts of your railroad don't need any gaps or feeders. These are the segments of track between turnouts that point in the same direction, Fig. 8-28, and also the places where a turnout points away from a stopper.

Now you can classify your railroad into three kinds of track segments. Each segment is bounded by a turnout or stopper at each end and here are the three kinds.

A. Segments bounded by turnouts pointing toward each other or toward a stopper need feeders. (Stoppers are gaps, insulated frogs, and the end of track).

B. Segments where turnouts point away from each other or away from a feeder need a gap or two.

C. Segments where turnouts point in the same direction or where a turnout points away from a stopper do not need feeders or gaps.

These three categories are really our same old rules in shorthand form, and you may prefer working with these but don't forget rule 5. It is an exception to category *C*.

The seven rules in this chapter will cover every kind of track pattern and are all you need for one-train operation unless you have a turning track. The next chapter shows what to do about a turning track.

Summary

A. Turnouts automatically route power down the same branch for which the points are alined. No other route gets power.

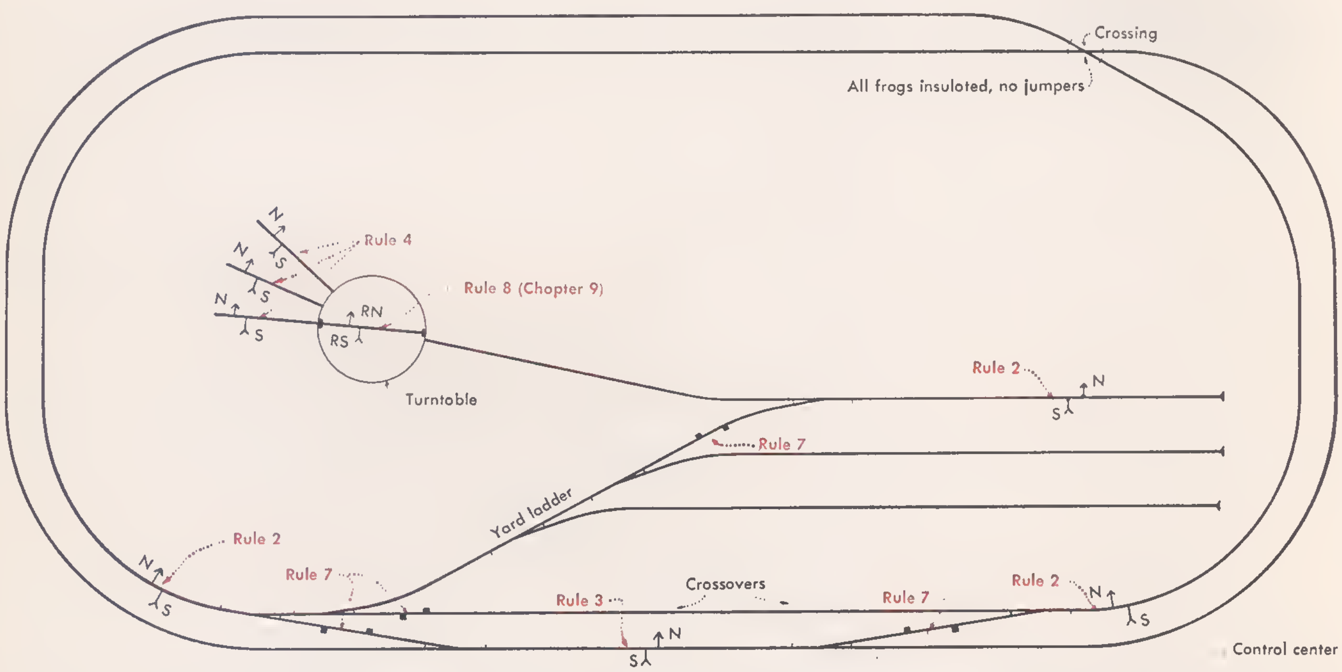
B. It is wise to reinforce this automatic power routing with contacts operated by the switch throw rod.

C. Short circuits in the track can be prevented by locating feeders and a few gaps according to seven rules. These rules are reprinted on page 43.

D. Gaps located close to the frog of a turnout are better for attended and realistic operation.

E. Gaps located at some distance from the frog of a turnout give a crude sort of automatic protection.

F. When there is a choice of placing gaps near one turnout or another, decide from which way you wish the control to come. Usually gaps should be near the second turnout in the direction of most frequent travel.



8 - 29 This is a typical two-lap oval railroad with a small yard and turntable. On this particular plan, gaps are needed at four places in addition to those in the crossing (crossings are explained in chapter 11). Four pairs of feeders are needed for the main and yard tracks and another three pairs in the roundhouse. The colored notes show just where the wiring rules apply. The RS and RN feeders at the turntable are explained in the next chapter, while the whole wiring routine is summed up in chapter 12.

Wyes and Other Turning Tracks

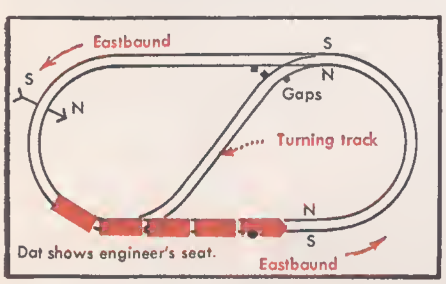
MANY a model railroader has finished his trackwork and wiring and checked his work to find it perfect. But when he started his train, he found the engine simply would not cross over the gaps on one of the tracks.

As soon as the locomotive nosed over these troublesome gaps it started to back up. Then it tried to move forward again and finally died.

Sometimes an engine just dies quickly and the circuit breaker trips, but the trouble may be caused by the same thing. Quite likely this fellow has a "turning track"* on his railroad.

Look at the oval railroad in Fig. 9-1 and imagine a train eastbound or moving counterclockwise around the line. After a few trips, throw one of the turnouts to guide the train across the diagonal track in the center. When the train crosses this diagonal, it will regain the oval on the other side but now it will be westbound, Fig. 9-2.

*In earlier material I have called a turning track a "reversing track." The old name caused confusion with another term, "reversing section," to the point that some folks thought the two were the same thing. The true meaning of turning track will come out in this chapter.



9-1 The return cutoff across this oval is also a turning track, see Fig. 9-2.

Notice how the train, without ever backing up, has turned to go in the other direction. Thus, the diagonal track can be called a "turning track."

A turning track is any place where a train changes from eastbound to westbound, or vice versa, as it runs through.

If a diagonal crossed the oval in the other direction as in Fig. 9-3, it would also be a turning track but this time it would turn westbound trains into eastbound. This happens no matter which way the train enters the diagonal.

These turning tracks are easy to find if your track plan is an oval. Some kinds of turning track are more subtle and I'll show you how to find all of them in the next chapter. The reason you must find them is that you need special wiring to prevent trains from stalling.

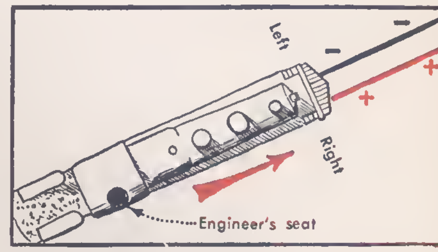
I'm going to show why you need special wiring, but first let me tell you something about locomotives.

Years ago the NMRA (National Model Railroad Association) accepted and published a standard way to wire locomotives. This standard ensures that all your locomotives will move in the same direction if they are correctly wired. It says:

"Positive potential on the right-hand rail shall produce forward motion."

The right-hand rail means the one at the engineer's side of the cab. Fig. 9-4 illustrates this standard.

Now let's go back to the engine in Fig. 9-1. Notice that the engineer's



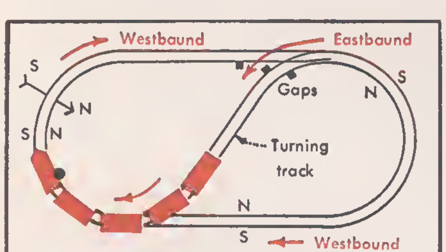
9-4 For forward operation the right-hand (engineer's side) rail should have positive polarity. This is true regardless of whether the rail happens to be the S or N rail. If you lift this engine and turn it the other way, the engineer's side of the cab will then be over a negative rail. This will make the locomotive back up. But since it is turned around, backing up would still be in the direction of the colored arrow. The only way you can make the engine go out at the left of this picture is to change the track polarity.

side of the cab happens to be above the *S* rail. Thus our direction controller toggle must be thrown so that the *S* rail gets positive polarity if our engine is to move forward and eastward.

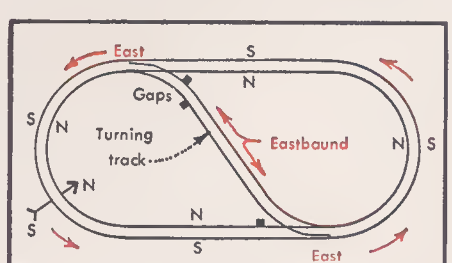
But look at Fig. 9-2. Here the engine has moved over the diagonal turning track and now it's going westward. Now the engineer's side of the cab happens to be above the *N* rail of the oval and this time it's the *N* rail that must be positive instead of the *S*. The engine is still going forward but its direction around the oval has changed.

The polarity changed at the instant the engine crossed the two gaps in the rails of the diagonal track.

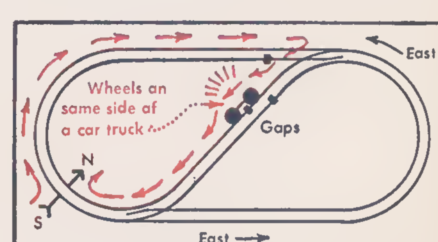
If you want your train to continue without interruption, then, you must throw the direction controller toggle at the very instant the engine



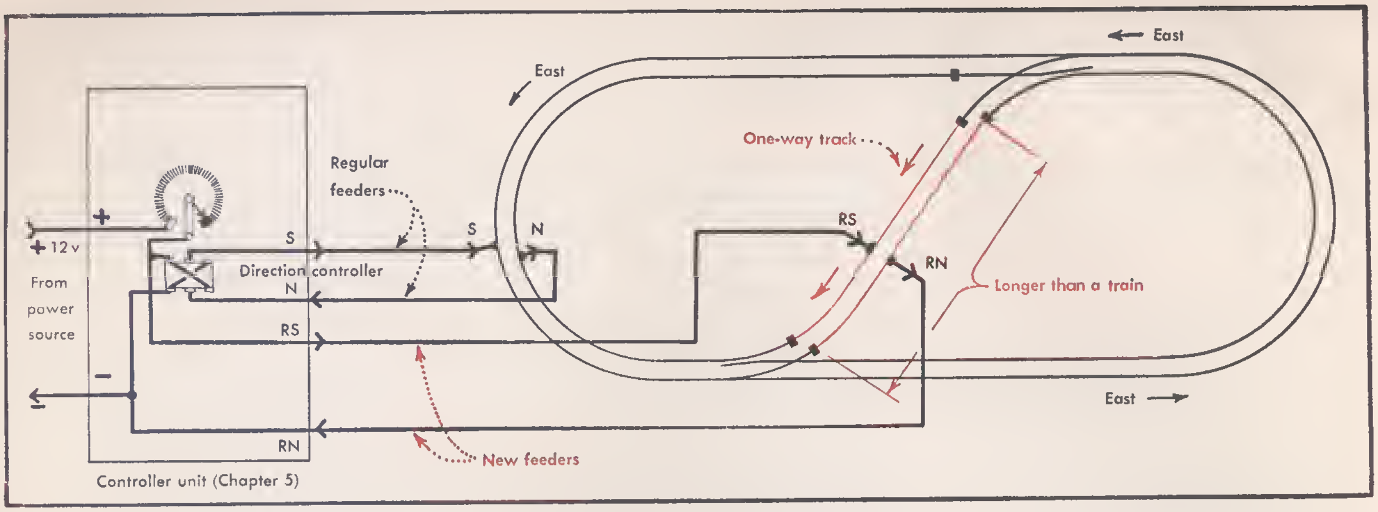
9-2 Whenever a train passes over this turning track it changes from eastbound to westbound even though it doesn't back up. This change of traffic direction happens no matter which is the entering end of the turning track.



9-3 Here the turning track changes westbound traffic into eastbound instead. The gaps in these drawings are located according to rules 6 and 7 but you will soon see that rule 8 will ask for two more gaps.



9-5 The wheels on the same side of a car truck can bridge a gap and cause a short circuit. The special wiring for a turning track, Fig. 9-6, overcomes this difficulty along with other turning track troubles.



9-6 Here is the complete wiring for a railroad with a turning track. Notice how the turning track is converted into a section isolated at each end with gaps in both rails. This section also has its own private feeders labeled RS and RN. One of these goes to the negative power feeder and the other goes to the moving wiper on your rheostat. Traffic over the turning track must always pass in the same direction with this arrangement. If you want to enter the turning track from either end, Fig. 9-7 will show how.

passes over those gaps. If you don't, the train will jerk to a stop or back up.

It isn't practical to try to time the operation of the toggle with the train, and even if it were you'd be in for trouble because the metal wheels of cars would short circuit the gaps as the train pulled over them. Fig. 9-5 shows this.

How to prevent trouble

Whenever you have a turning track the same problems exist and their solution is very simple. Just make an "isolated section" of track long enough so that your entire train can run in it while you throw the direction controller to reverse the polarity on the main part of the railroad.

Look at Fig. 9-6. Notice how we now have gaps at both ends of the diagonal turning track and that this track has separate feeder wires (*RS* and *RN*) that do not come from the direction controller toggle.

Now it's easy to see that you can change the polarity of the *main line* without affecting the train in the *isolated section* since the main direction toggle has no effect on the section.

The isolated section must be at least as long as any train that will use it (to prevent short circuits from car wheels) and it must always have gaps in both rails at each end.

There is one more thing we must do to make our section perfect. Notice in Fig. 9-6 that positive electric pressure always reaches rail *RS* of the isolated section. This would mean your trains would always have to enter the section from the top and leave at the bottom. Usually you will want to run trains the other way as well, so you need another direction controller toggle as in Fig. 9-7.

Back in Fig. 5-8 I showed you how to build a special controller unit that includes the extra toggle. You can also add an auxiliary direction toggle to any existing controller unit you might already have, and I'll show how later in this chapter in Figs. 9-20 and 9-21.

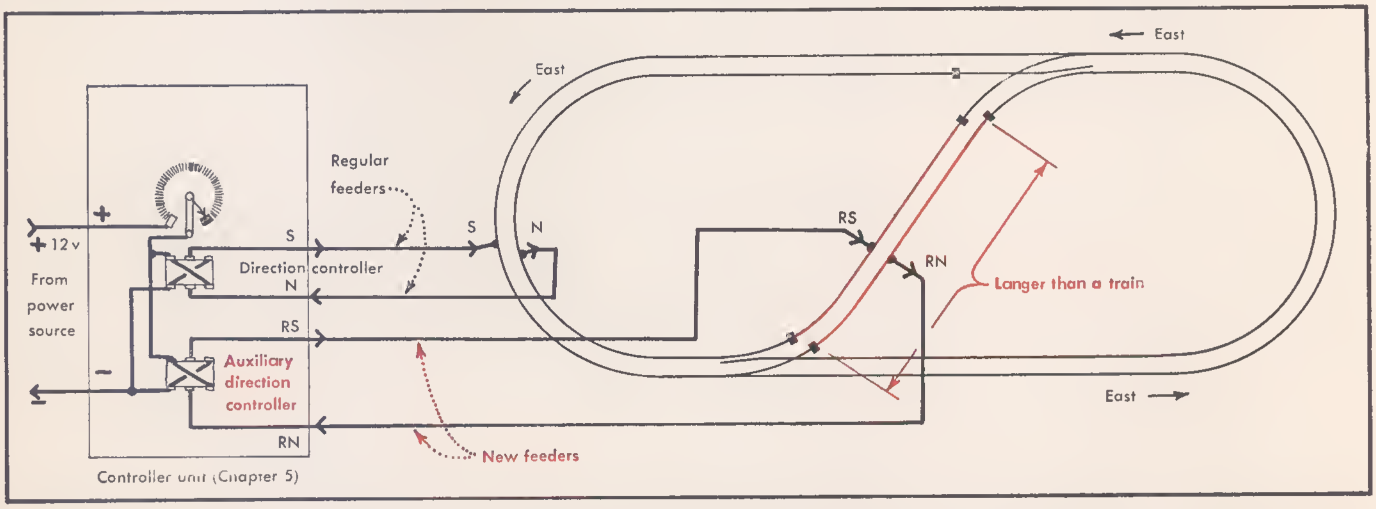
Now we have the whole story on turning tracks and here's a rule to sum it up for future use:

How to wire wyes, loops and other turning tracks

If you have a turning track on your railroad you need an isolated section to hold a train while you reverse the polarity of the track beyond.

A. This isolated section must be at least as long as the longest train that will use it.

B. Every end of the section must have gaps in both rails. (A section that includes turnouts might have more than two ends; all need gaps.)



9-7 By adding another dp. dt. toggle to your controller unit you can run trains in both directions over the isolated section as well as on the rest of the railroad. You can add this valuable toggle even when your controller is part of the power source.

C. The section must have its own feeders separate from the feeders to other parts of the railroad. Mark these feeders **RS** and **RN** to distinguish them. **R** stands for "return track."

D. The **RS** and **RN** feeders should go to their own direction controller toggle separate from the main direction controller.

I've shown you one kind of turning track and only one of several ways to arrange the isolated section. There are other kinds of turning track including turntables, turning wyes, return loops and cutoffs, return crossovers, and the third side or leg of junction wyes. With each of these, there are several places where you can locate the gaps and put new feeders to isolate a section.

Turntables

Probably the most familiar turning track is the turntable itself. Fig. 9-8 shows the usual way to wire this. Current to one of the turntable rails is fed through the metal center post, and the other rail is fed through the wheels that ride on the ring-rail in the turntable pit.

Notice that the turntable is really an isolated section. The gaps at each end are the breaks between the table rails and the approach rails. The section is also as long as the longest "train" that will use it.

The operation of the two direction toggles is the same as before. In fact, it's the same at all turning tracks. While the train is in the isolated section, turntable or otherwise, you throw your main toggle. This lines up the tracks the engine is about to use so the polarity will be right.

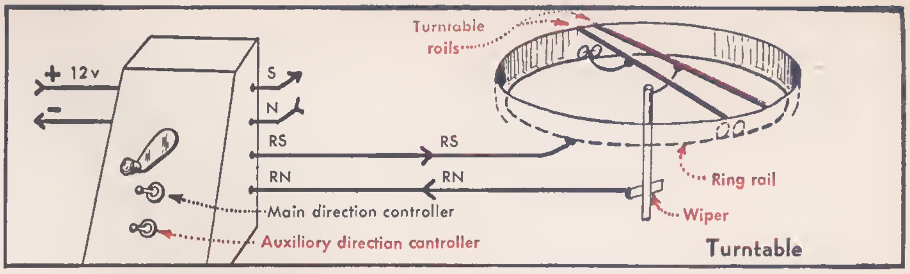
You use the other toggle only to line up the isolated section when a train will enter from the other end. This is quite often on a turntable because the "other end" is just as likely to be toward the approach track as not. On other turning tracks most trains are likely to enter from the same end.

Return loops

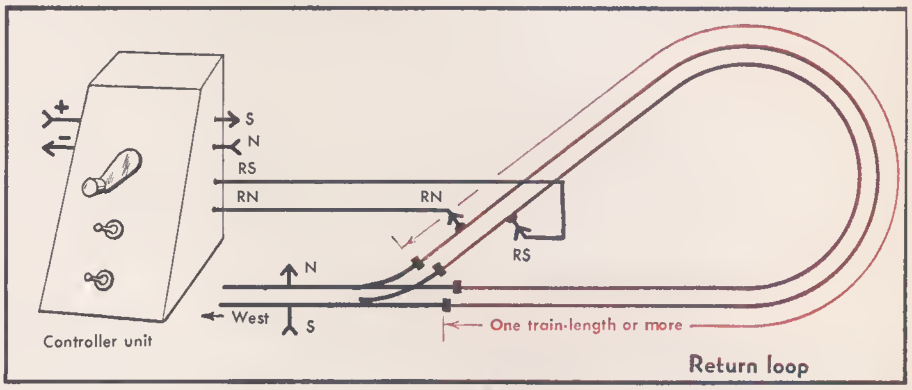
The next most common form of turning track is the return loop, Fig. 9-9. Here the very same thing happens as at a turntable, except that the engine leaves by a different branch of the approach track. The letter *R* which we add to identify the feeders to any turning track comes from this word "return."

Our very first example, the diagonal across the oval, was really the same as a return loop, Fig. 9-10. In this form it's called a "return cut-off."

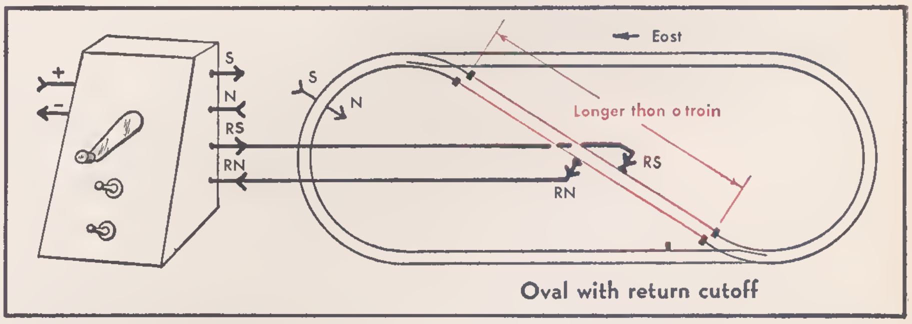
If you squash an oval railroad into



9-8 The ring rail and central shaft make a convenient way to pass electricity to the rails of a turntable. If the table is made of metal it must be insulated either from the shaft or the roller truck or both to prevent a short circuit. RS and RN go to an auxiliary direction controller toggle wired exactly as in Fig. 9-7. Approach rails around the turntable are not shown in this drawing. You wire them just as you do any other part of your track and they are fed from the regular S and N feeders.



9-9 A return loop is like a turntable with the track bent into a horseshoe. The RS and RN feeders of all examples must go to an auxiliary direction controller toggle in the controller unit, power source, or on a separate panel. S and N feeders go to the regular direction controller as usual.



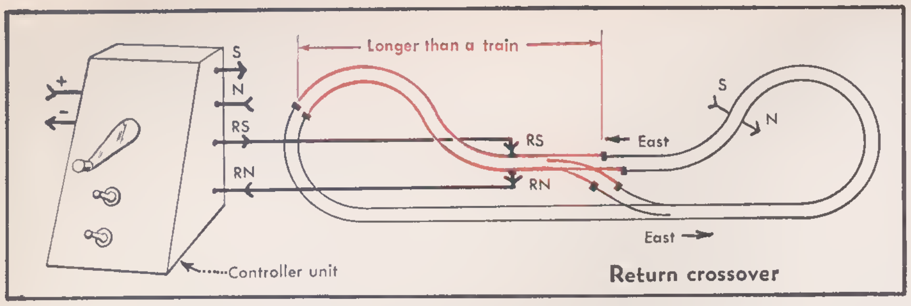
9-10 I have repeated the oval with return cutoff so all common kinds of turning track will be shown similarly in the series of drawings on this and the next pages. If the isolated section (with color overprinting) is too short to hold a train, extend it in one direction or the other as in Fig. 9-11.

a dog-bone pattern, you will have a sort of double track running down the middle, Fig. 9-11. Notice that counterclockwise or eastbound is in the opposite direction on one track from the other. This means that any crossover between these tracks would automatically become a turning track, too. Now you don't have enough room to locate the isolated section in the crossover because it wouldn't be a train-length long. The answer is to extend the isolated section into one of the main tracks.

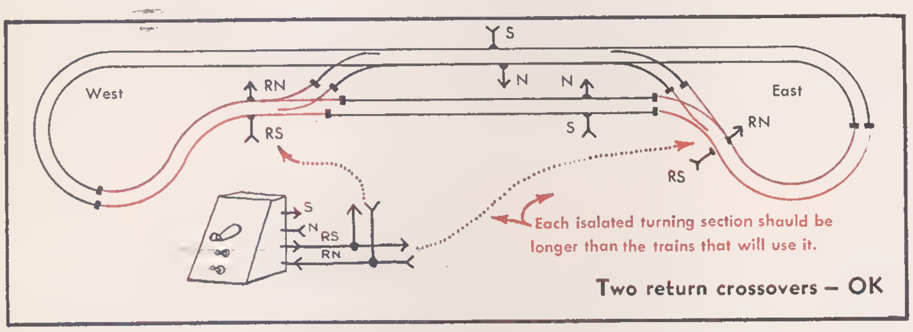
You can extend an isolated section in one direction or the other from any turning track as long as some part of the section and the turning track overlap. This gives us lots of elbow room to locate our isolated section in the most advantageous place.

A neat use of this trick may be applied when you have two crossovers nearby on the dog-bone pattern. At first you might arrange the isolated section as in Fig. 9-12, but this is wasteful. The crossovers are about a train-length apart, so you could locate one isolated section between them and cut the wiring in half, Fig. 9-13.

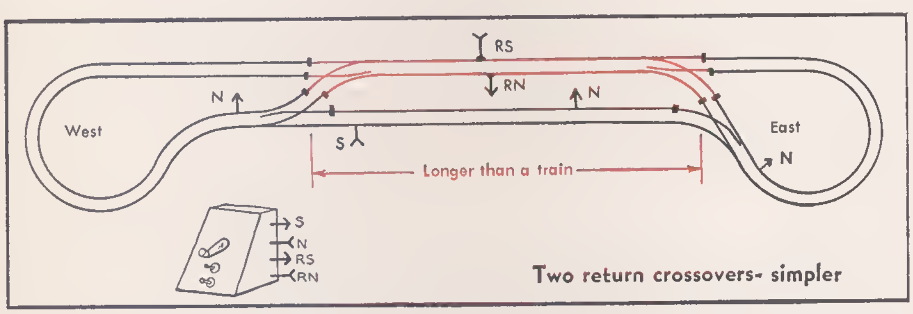
You can use this trick on many other track patterns, too; in fact, anywhere two or more turning places are nearby. A common example is on the combined oval and figure-eight plan, Fig. 9-14. At first you might think



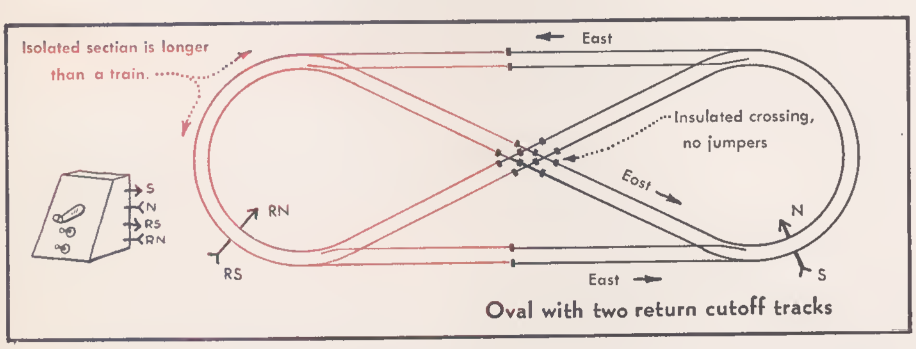
9-11 An oval railroad pattern can be pulled to any length so that it becomes a sort of double track line with loops at each end. Any crossover in this dog-bone pattern is bound to be a turning track. Since the turning track is too short to hold a train between turnouts, its isolated section must be extended into one main or the other (not both). Gaps in both rails terminate the section at all three or more ends.



9-12 When a dog-bone railroad has two or more crossovers you might at first think each crossover would need a separate isolated section. Sometimes this is the best idea, but more often a single isolated section will serve for both of the turning tracks. See Fig. 9-13.



9-13 This is the same as Fig. 9-12 except that a single isolated section serves two turning tracks. This combination is practical when turning tracks of any kind are within a reasonable distance of each other.



9-14 Here again you might expect to install two separate isolated sections for the two diagonal turning tracks. This isn't necessary if you make one end of the oval an isolated section. This section must extend into the two diagonals at least past the frogs of the turnouts. The reason I extended the sections in this example as far as the crossing is that it then makes use of the insulated frogs of the crossing as gaps and saves cutting a new pair nearer to the turnouts.

you'd need two isolated sections on the two diagonals. It is much simpler if you put the isolated section at one end of the oval and let it extend into each diagonal just a bit.

Getting back to the dog-bone, sometimes you are going to use those crossovers a lot in switching moves, and sometimes the loops at the ends are used less often than the crossovers — perhaps only to turn trains after their journey. This might be the case on a railroad such as the one in Fig. 9-15.

If the two main tracks go in opposing directions as before, all switching moves over crossovers will involve isolated sections and you'd be throwing direction toggles almost continuously.

Then why not do the isolating in the end loops so both main tracks run eastward in the same direction? Fig. 9-16 shows how the wiring would be more simple.

What we have really done is to say, "This may be a squashed oval, but we're not going to use it much for continuous running. We are going to run our trains in real railroad style from Westville to Easton and from Easton back again. Even though we have a sort of continuous line, we are more interested in operating it as a point-to-point system."

Thus the way you intend to run your railroad will affect the way you decide to wire it. You can even arrange the wiring for both kinds of operation if you want to go to that much trouble.

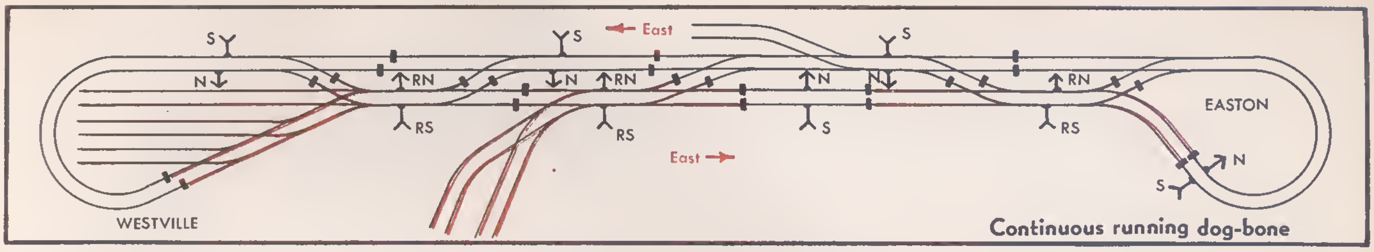
Wyes

Wyes are used in two ways — for turning engines or whole trains, and as the third side at an important junction. Let's look at the junction scheme first. Suppose you have a main line and a secondary route that separate at an important junction and converge later on, Fig. 9-17. This might be part of a point-to-point railroad or it might happen on one side of an oval system.

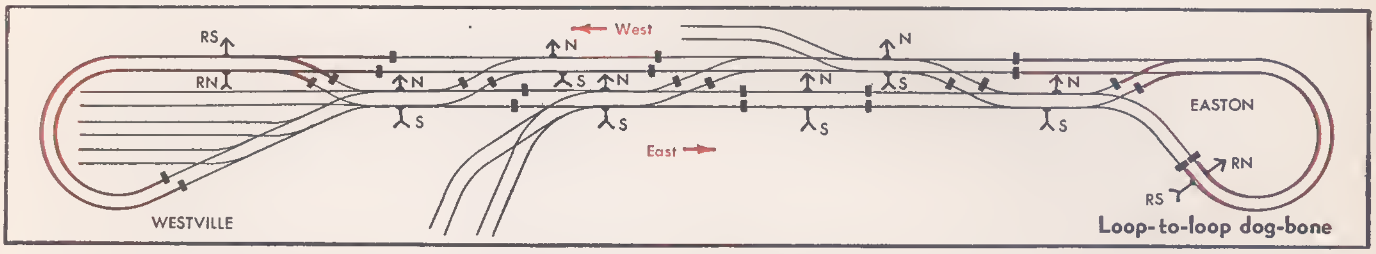
At one of the two junctions you have a third side forming a wye. And when a train approaches this wye from the east it has a choice of routes. It can continue west along the main track or it can take the third side of the wye and if it does it will come out going east. Again you have a turning track.

The isolated section can be located in the third side of the wye if that side is long enough to hold a train, Fig. 9-17. If there is not enough room, the isolated track must extend into either the main or branch. It is better to extend into the branch and then the wye would be wired as in Fig. 9-18.

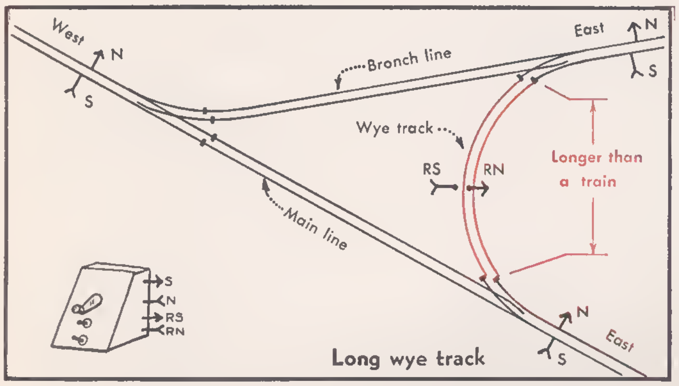
A turning wye is about the same ex-



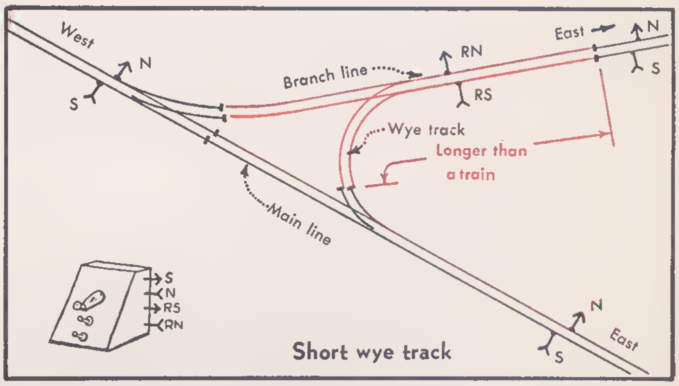
9 - 15 This dog-bone railroad is typical of many medium-sized railroads and some large club systems. If you wire the railroad in the usual way you will need isolated sections near each crossover along the main lines. I've indicated these with color laid over the rails. Fig. 9-16 shows an alternate method which will usually save wiring and be easier on switching crews and trains making wrong-main movements.



9 - 16 The same track plan is now treated as a point-to-point (or loop-to-loop) railroad instead of an oval. Each time a mainline train reaches the ends at Westville or Easton it must change direction by passing through the isolated section of a turning track. This eliminates the need for many isolated sections along the main line. Again color shows which rails are fed through the auxiliary toggle on your controller unit.



9 - 17 A wye track between a main line and branch is always a turning track. If it is long enough you can work the isolated section between the turnouts, but when space is tight use the Fig. 9-18 scheme.



9 - 18 When the wye track at a junction is too short to hold a train, extend its isolated section into the branch (or main but not both) as far as necessary.

cept that an engine must back up during part of its run around the track. For this reason it is more convenient to put the isolated section along one of the legs as in Fig. 9-19. This section must include the turnout.

Control and feeders

If you have a power supply with built-in controller unit and you also have a turning track, the power supply should have two direction control toggles instead of the usual one. The easiest way to convert is to build a small panel nearby with the two toggles and ignore the toggle on the pack, Fig. 9-20.

If you are more industrious, mount a second dp. dt. toggle on the panel of the pack and rewire the output from the rectifier as shown in Fig. 9-21.

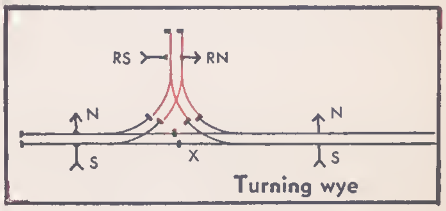
Each isolated track must have feeders to connect to the extra direction toggle on your panel. Rules 2, 3, and 4, from chapter 8 will show just where to locate these feeders. You may also need feeders in the approaches to this section and the same rules will help again.

If you are in doubt, or if your track plan is so distorted that you might not recognize all the turning places, the next chapter will show you how to find them.

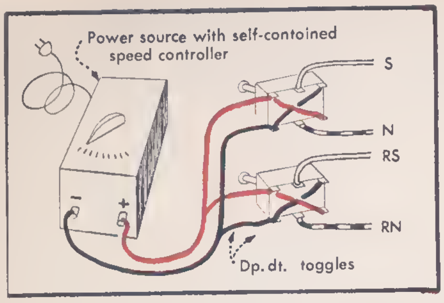
Since at turning places you'll find that trains will enter the isolated section more often from one end than the other, you could label the two ends of the turning track "normal entrance" and "reverse entrance." This gives us the clue as to which feeder to a turning section should be labeled *RS* and which *RN*. Make the *RS* adjoin the *S* at the normal entering end, Fig. 9-22.

Polarity indication

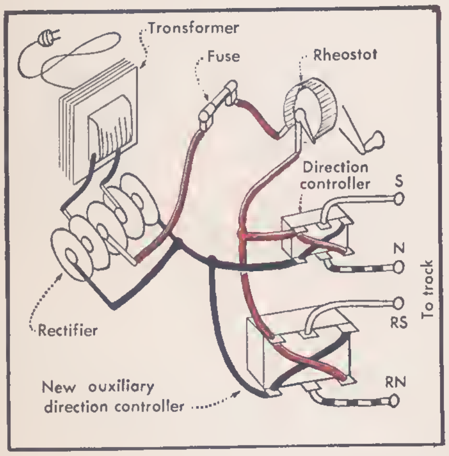
The handle of your auxiliary direction toggle will serve as an indicator to show you whether or not your turning tracks are lined up properly for an approaching train. If the connecting wires are loose enough to per-



9 - 19 A turning wye needs an isolated turning section on one of its legs. Notice that in all three types of wye you must have gaps in at least one and usually both rails of each side. In this example one gap at X can be omitted as you will see later on.



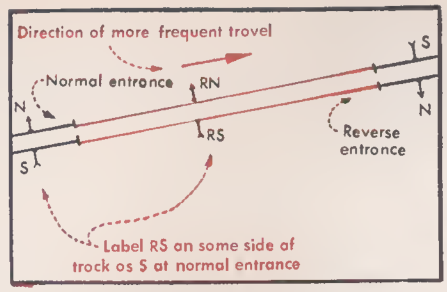
9 - 20 Commercial power packs which contain controller equipment usually have only one direction controller. But if you have a reversing track you need two. This shows how to wire two dp. dt. toggles on a separate panel to handle main and auxiliary direction control.



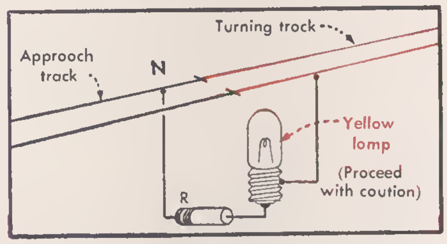
9 - 21 If you open the case of your combined power pack and controller unit you will find that it is wired something like this. All you need to add is the extra dp. dt. toggle at the lower right and the four wires that connect to it. Occasionally you may find a power pack in which the red wire of my drawing goes directly to one of the toggles and then to the rheostat. Rewire as in this sketch for better control of turning tracks. In place of the fuse you may find a circuit breaker and there may be other elements not shown, such as lamps.

mit it, you can loosen the nut of the toggle and revolve the toggle so that the handle points to the right (or downward if you prefer) when the trains can enter from the "normal" end.

Sometimes you'll want to run a train into a turning track through the "reverse" end and these are the only times when you'll ever have to throw the toggle to its "reverse" position.



9 - 22 The **RS** feeder to an isolated turning section should be on the same side as the **S** rail at the end where trains enter more frequently.



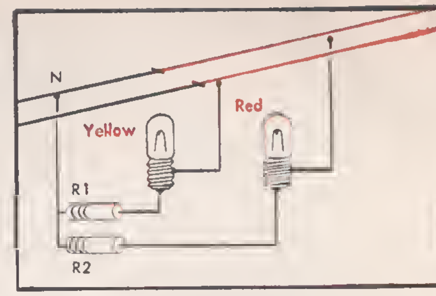
9 - 23 This lamp will glow when it is safe for a train to cross the gaps between an isolated turning section and the approach track.

The toggle alone is a good indicator, but if trains are going to make reverse entrances often you may want to add a lamp to one or both ends as in Fig. 9-23. The lamp or lamps can be on your control panel or you can put them in signals beside the track.

Each lamp is connected to diagonally opposite rails at the gaps where the approach and turning tracks meet. When a lamp is illuminated you know a train can pass over the gaps without any short circuiting. You could make the lamp green just as well as yellow. I chose yellow only because it means proceed with caution, a good idea at turning tracks.

The firecracker-like device at *R* is a resistor. You won't need it if you use 18 v. bulbs, but you may find it more convenient to use 6 v. radio-dial bulbs. Then use a resistor rated at 51 ohms (or a little more) and 2 w. You could also use a second 6 v. bulb in place of the resistor if you wish.

Fig. 9-24 is a modification of the polarity indicator which uses two lamps. When polarity is not lined up,



9 - 24 This is the same as Fig. 9-23, but a red lamp has been added to show when it is not permissible for a train to cross the gaps.

the red lamp will warn you. This makes a more interesting signal.

If your railroad is simple you may already know whether you have a turning track or not and you may know where to put your isolated sections if you need them. If you are sure, you can skip right over the next chapter.

Summary

A. A turning track is that place at which a train changes from eastbound to westbound or vice versa as it passes through. Turning tracks are also called reversing tracks.

B. An isolated section must be located near each turning track. This must be separated from the rest of the railroad by gaps in both rails at all ends of the section.

C. The isolated section must be a train-length or more between ends.

D. The feeders should be marked *RS* and *RN* to distinguish them from other feeders and they should go to their own separate direction toggle.

E. You will find turning tracks wherever you have diagonals across an oval, crossovers on a dog-bone, return loops, wyes, and turntables.

F. You can extend the isolated section beyond the turning track as long as the two overlap.

G. By extending one way or the other (not both) you can locate the isolated section where it will hold a full train and where the wiring will be simpler.

How to Find Turning Tracks

WITH a simple track plan you may have no difficulty in spotting wyes, loops, and other turning tracks. But sometimes these places are so innocent looking that you miss them entirely. That's why I worked out this pencil-and-paper routine to find all turning tracks on your railroad and to help you plan what to do about them.

The idea is to divide your system into routes according to the way you want to run the trains.

In the oval example with a diagonal track back in Fig. 9-1, you could call the outer track the "main route" and the diagonal could be another "route." Any track plan can be divided into two or more routes in this same manner.

Next, you assign eastbound and westbound directions to the most important route and try to make the other routes join, going in the same direction as much as possible.

Where routes cannot join, both going eastward or both going westward, you have found a turning track, Fig. 10-1.

Get some tracing paper or else make a copy of your master track plan. If you have some colored pencils, they'll help a lot in keeping each route distinguishable. Don't mark up your master plan because the hokus-pokus you're going to do would obscure all the more valuable information that belongs on the main plan. For this work let one line represent both rails of each track.

The process may take two minutes or an hour depending upon how fancy your track plan is. We'll do it in three steps.

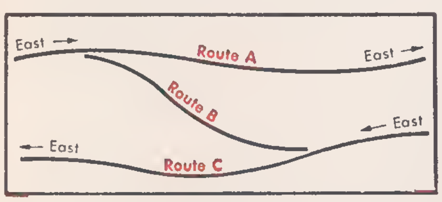
A. Mark out each route starting with the most important.

If you have one or more *continuous* routes, ovals, figure eights, twice-around ovals, or the like, mark the most important of these first. Draw a line over the entire length but do not mark any branches, Figs. 10-3 and 10-4. Ignore the solid triangles for the moment.

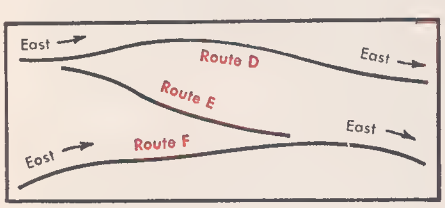
If there is another continuous route, draw the next most important and so on until all continuous routes are marked. Use a different color for each route if you can, or else label them *A*, *B*, *C*, etc., at several points along each, Fig. 10-5.

If any route connects into one you have already marked, leave a little break in the line at the junction, Fig. 10-1. This will automatically show the more important route as running right through the turnout and the branch as ending there.

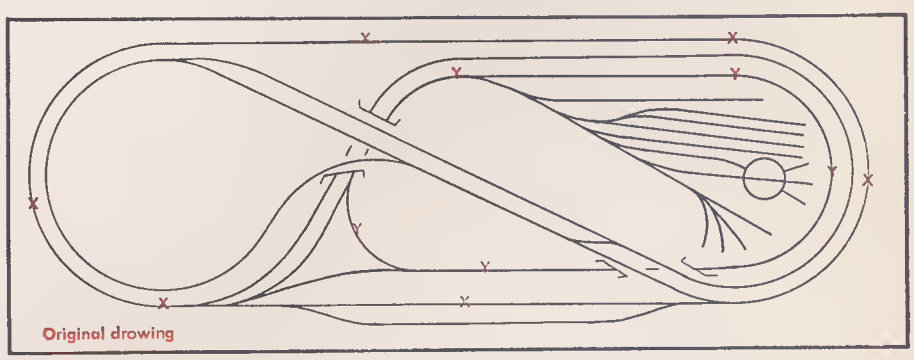
When you have all the continuous routes, add the important point-to-point routes, and finally any connecting tracks that may remain. Each is a separate route and has a color at least different from the routes it joins



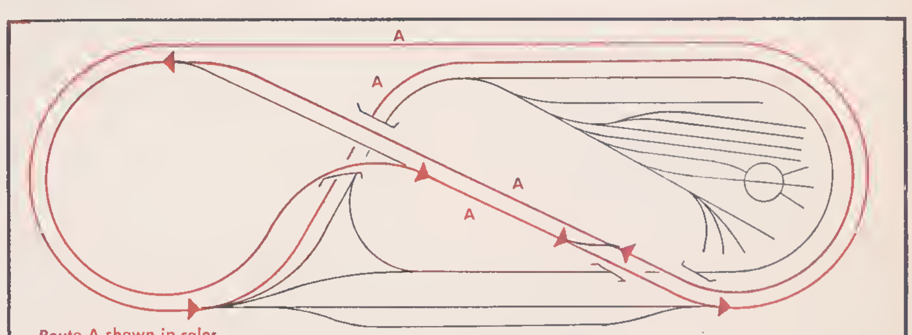
10 - 1 This is a small part of a railroad system where a short route connects with two important lines. Conditions on another part of the railroad make it necessary that the traffic directions be opposite on routes **A** and **C**. Thus when a train passes from route **A** over **B** to route **C** it must change direction from eastbound to westbound. Route B, then, must be a turning track. Now look at Fig. 10-2.



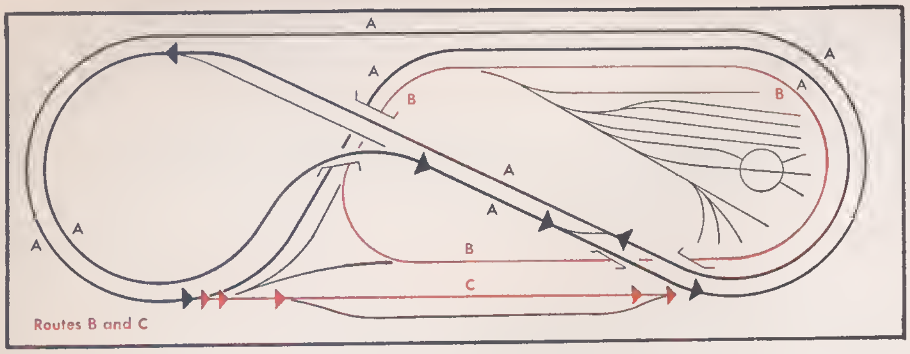
10 - 2 At another part of the railroad, routes **D** and **F** are connected by a similar cut-off route. But this time the traffic directions on **D** and **F** are the same so trains do not change direction as they pass over **E**. So the trick of finding turning tracks will depend upon traffic direction as well as track pattern. That's why I have emphasized eastbound and westbound terms from the beginning.



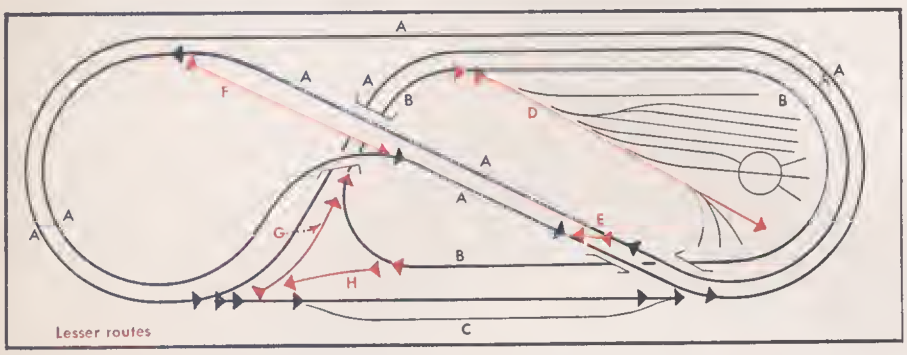
10 - 3 I have purposely chosen a confusing track plan for our example in this chapter because it will show how to tackle most turning track situations. The original plan was made by Ralph Butterfield and you can find it in the book **Track and Layout**. At first glance you will find two continuous routes, x and y, on this plan, but are these the only ones? Which is most important?



10 - 4 I think the most important continuous route is this one because it covers so much more ground than the x and y of Fig. 10-3. It is a dog-bone folded back on itself. The route has six turnouts, and later you will see why I put the triangular arrowheads over each junction.



10 - 5 Now we can go back to routes x and y and give them the dignity they deserve. They become **B** and **C**, but notice how most of **C** has been absorbed by route **A**. I couldn't put arrows on **B** yet because it doesn't connect with **A**.

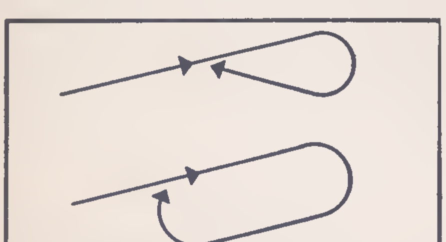


10 - 6 Finally the lesser routes are added. The tracks with light lines are only stubs or simple passing tracks and can be ignored because, except for the turntable, they cannot be turning tracks. Notice how all arrowheads along any route point the same way. If you get one turned the wrong way you will be in for sure trouble.

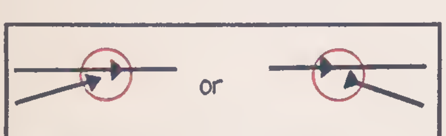
at each end. Be sure not to miss the very short connecting routes in the diagonal of each crossover.

If a route doubles back on itself, leave a break in your line at the turnout where the route rejoins, Fig. 10-8.

The reason I suggest marking continuous routes first is that these are usually the ones with the heaviest traffic. However, if you think point-to-point operation will be more important on your railroad, mark the point-to-point routes first.



10 - 8 Sometimes a route will rejoin itself. Here are the two ways this can happen. The upper situation creates a turning track.



10 - 9 Mark agreeable junctions thus.

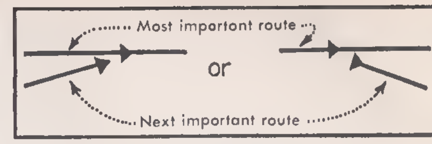
The only tracks that remain unmarked are stubs (which merely run from a turnout to a bumper) and simple two-turnout passing tracks that connect right back into the same track they branched from. Now look at Fig. 10-6.

B. Assign a direction to each route.

Start again with the most important route and mark solid triangular arrowheads at each end and at every junction along each route. The arrowheads should all point in the direction of travel for an eastbound train. This would be counterclockwise on an oval, Fig. 10-4. If the route is complex like a figure eight, you can make eastbound counterclockwise at the most important part of the route.

This first route is the backbone of the railroad, and we'll arrange the directions assigned to other routes to fit with the main route as well as possible.

If your second most important route branches from the main route, make the starting arrowhead at the junction point the same way as the mainline arrowhead, Fig 10-7. If the next most important route doesn't connect with the main, take the most important route that does branch away, and mark its arrows instead.



10 - 7 Where a new route joins a more important one the traffic direction on each should agree. Arrows show traffic direction along the entire length of each route.

Gradually assign directions to each route until there are two arrowheads at every junction. Always favor the more important route when choosing a direction for a lesser route.

Sometimes a route will branch from the main at two places. Here also you start at the more important junction—the one that trains will use more often. The other junction may come out with arrowheads opposing and that's all right. See route *F* in Fig. 10-6.

The junction where a route doubles back on itself will often, but not always, be this way too, Fig. 10-8.

Look over each route again and make sure that the end arrowheads and all the junction arrowheads point toward the same end of the route. If you get this wrong you will have trouble. Check to see that all important junctions have two triangle marks. Only turnouts leading to stub and passing tracks may have less.

C. Locate the turnouts where the direction of the branch conflicts with the main track. The branch tracks at these places are turning tracks.

In this step you examine all junctions to see if the two arrowheads agree. Where the arrowheads agree, draw a light circle to show things are all right and go on to the next turnout, Fig. 10-9. If arrowheads point in opposite directions, Fig. 10-10, mark the branch track with crosshatches all the way to the next important turnout (one with two arrowheads).

The crosshatched zones are your turning tracks. Whenever a train passes through these zones it changes from eastbound to westbound or vice versa, Fig. 10-11.

Where to put isolated sections

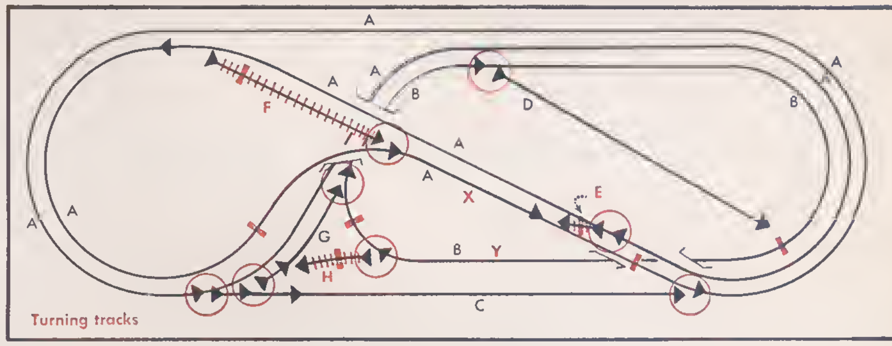
After you have marked all of your turning tracks it will be easy to plan the isolated sections you need for proper operation.

The isolated section must be as long as the longest train that will use it. If you can locate this entirely within the crosshatched turning zone and there are no other zones nearby, this will be the best solution.

If the crosshatched zone is too short, as in a crossover, your isolated section will have to extend one way or the other, not both, however.

The best direction for extension is

10 - 10 Where junction arrowheads do not agree, mark the branch track with crosshatches all the way to the next junction turnout.



10 - 11 Here the agreeable junctions have been circled. This process reveals three that are not agreeable. The short, colored crosshatches are added along the branch at each of the three to denote turning tracks. Although there are three turning tracks, you need only two isolated sections to handle them because E and F are reasonably close together. This would locate one isolated section at X. How about the other? If the turning track at H were extended to the left these turnouts would be involved, so I would prefer to put the isolated section at Y. The heavy colored crossbars suggest where to put the gaps for each isolated section.

usually the one on the least important route or the one which contains the fewest turnouts.

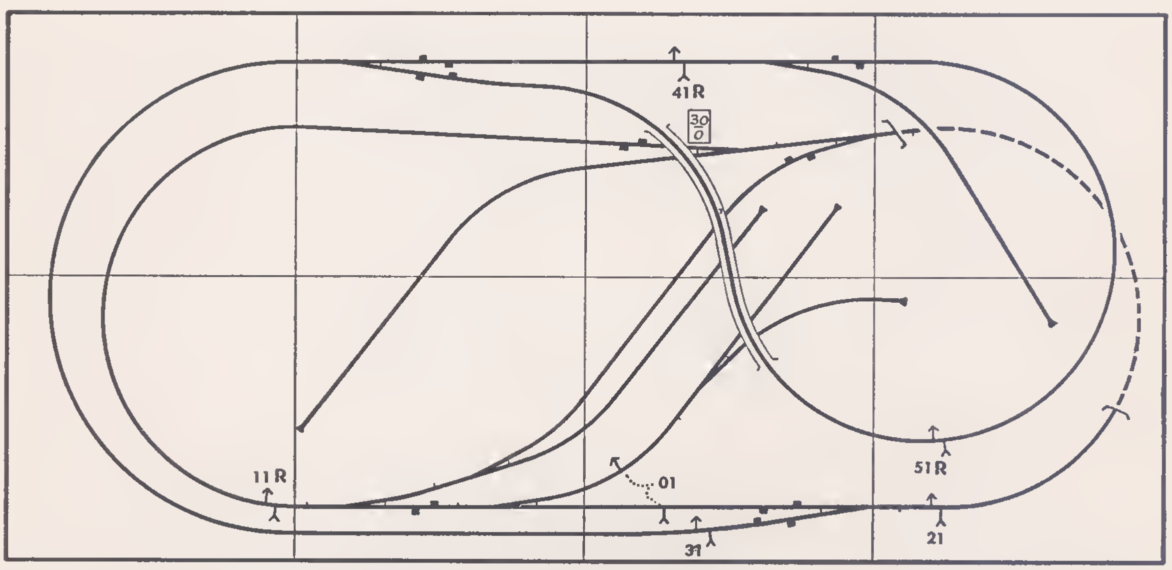
If two crosshatched zones are near each other, try to arrange one isolated section so it extends into both zones.

When you have decided on the boundaries, mark the gaps on each rail at each (and every) end right on your master track plan. Then check back to the rules for track wiring in chapter 8 to see where you need feeders.

You may need feeders in the isolated sections, and you may need them in any of the approach tracks beyond where you have just added gaps. Mark the feeders within the isolated section with *RS* and *RN* and feeders outside this section with *S* and *N*.

Summary

The three steps in large type are the summary for this chapter.



10 - 12 Track plans in the **MODEL RAILROADER** are published with gap and feeder symbols already in place. The letters S and N for individual feeders are usually omitted but you will find block numbers nearby to help identify each pair of feeders. Also a letter R is used to indicate blocks which are isolated sections for turning trains. Gaps and feeders are indicated as needed to prevent short circuits, as you might expect, but also extra gaps and feeders are usually provided to help when you are ready to run several trains at the same time. More about multi-train track wiring and operation will be found in part two of this book and particularly in chapter 18, which deals with block wiring.

Crossings and Fancy Trackwork

THE easiest way to wire a crossing is to insulate two of the frogs and add jumper wires around them as in Fig. 11-1. You can insulate a frog by cutting gaps in each of the four approach rails, or you can make the frog out of plastic or wood so it cannot pass electricity.

This crossing is fine for railroads that will always use only one train. Since the same feeders supply both routes, a different wiring scheme will usually be better for multi-train railroads. When you wire this, be sure you arrange the crossing so the *S* feeder will be upon the south rail of *both* routes. Gaps will be needed in any approach track that leads to the frog end of a turnout.

A crossing with all frogs insulated is almost as easy to make, and it's better because you can use separate feeders for each branch. This is important when you want to run two or more trains at the same time, but it makes no difference if you will always run only one train, Fig. 11-2.

You will not need extra gaps in the approach tracks when you use this kind of crossing, but the rules in chapter 8 may call for some feeders.

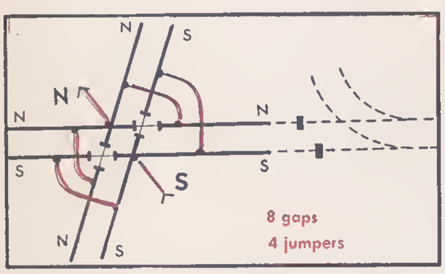
Crossings sold already-made often have jumper wires as in Fig. 11-3. This is sometimes a big help and sometimes a nuisance. You can cut the wires and treat the crossing as we just did, or you can leave the wires in but then you use the rules of chapter 8 differently. This time you ignore the crossing entirely when you follow the rules because the jumpers carry the current across just as though the track were continuous, Fig. 11-4.

These simple crossings have dead segments in the track where the frogs are insulated. If the angle is sharper than 45° some locomotives may stall over the dead spots. One remedy is to cut four more gaps and wire the crossing as in Fig. 11-5. The frogs are still dead but their length is shortened.

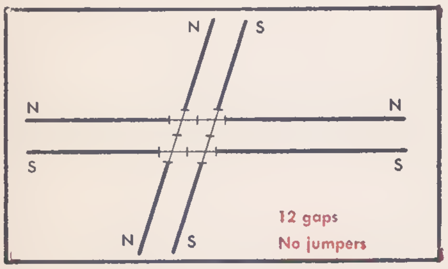
Another way to prevent stalling is to wire your crossings so that the metal frogs will get power at all times. This requires a toggle on your control panel, and you must throw the toggle each time a train approaches by the other route.

You can do this with a dp. dt. toggle, but for two or more train operation a 4p. dt. (four-pole double-throw) toggle would be better. Fig. 11-6 and Fig. 11-7 show the two methods. This type of crossing has no dead spots at all.

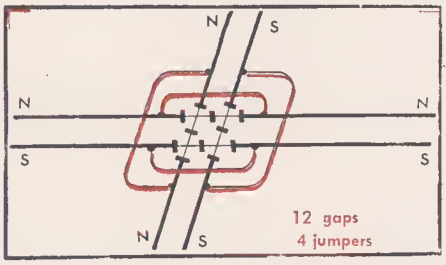
A crossing with movable points can be wired just like two turnouts, Fig. 11-8. If you want separate feeders for each route, do it as in Fig. 11-9. This again is more useful if you plan to run two trains later on.



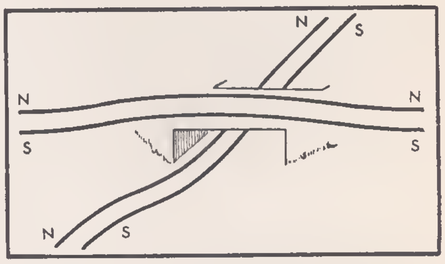
11 - 1 The simplest crossing for one-train railroads requires only two insulated frogs (four gaps around each). Jumper wires pass electricity around the frogs. If any branches have turnouts pointing away from the crossing, those branches should have gaps in both rails as shown to the right. This crossing is not so suitable for railroads with more than one train.



11 - 2 A crossing with all frogs insulated is satisfactory for multi-train as well as one-train railroads. Wiring with this crossing is always simple too.



11 - 3 Here jumpers are added to the crossing of Fig. 11-2. This carries electricity across along each route. Fig. 11-4 shows the idea. Feeders are not shown in these figures because their location will depend upon the rules, chapter 8.



11 - 4 Electrically this is the same as Fig. 11-3. I drew it to show that each of the two routes is as independent as though they were on different levels.

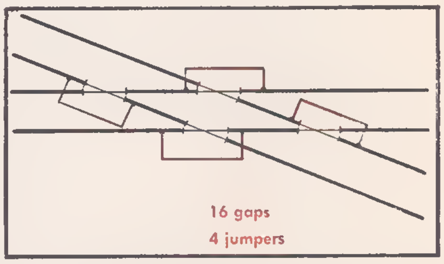
Spring turnouts

Turnouts with spring loaded points are not used much on the prototype but they are becoming increasingly popular at remote sidings. On a model railroad they can be used at sidings and at the ends of double track. Fig. 11-10 shows how to wire them.

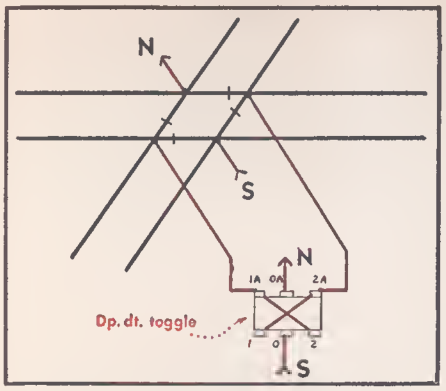
The points must be electrically independent which makes it more difficult to construct a spring turnout. When you make your tie rod, use plastic or fiber or metal with plastic inserts so electricity cannot flow from one point rail across to the other. Fiber strips with rivets forced through at the proper places provide one of the easiest ways to make tie rods. Then you can solder the points to the rivets.

Each point rail can have its own pivot made of a fishplate crimped to keep the rail from working out.

The frog of a spring turnout must



11 - 5 Short sections of live rail between crossing frogs help short wheel base engines to get across. This is particularly helpful with crossings at small angles. Although this crossing has jumpers, they do not let power flow all the way across so this is electrically equivalent to a crossing without jumpers when you apply wiring rules.



11 - 6 This scheme requires a minimum of gaps and has na dead spats. The dp. dt. taggle must be thrown one way or the other depending on which route is in use. A relay with two sets of make-break springs cauld replace the toggle for automatic operation.

also be insulated with four gaps or you can make it of wood or plastic. Add six jumper wires and the job is done.

You do not get the advantages of automatic power routing when you use a spring turnout, and the power will reach both branches at the same time.

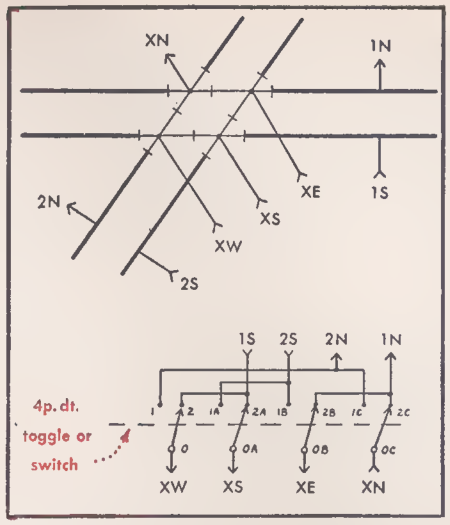
Gantlet track

Gantlet track, also called gauntlet track, is that track on which parallel routes interlace to save space. This happens in narrow tunnels and over bridges on double track lines and is sometimes used where the points of a turnout must be located far from the frog. Figs. 11-11 and 11-12 show the wiring for each.

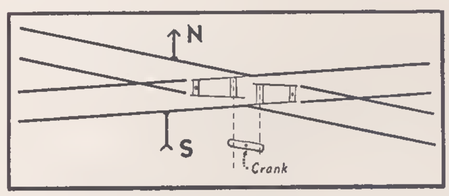
Slip switches

I've seen dozens of ways to wire a slip switch and which is best depends a lot on how you build the switch. One scheme uses metal tie rods for the six pairs of points and you get the same kind of automatic routing you'd get with ordinary turnouts. The only precaution to take is that the two sets of points should not touch each other if thrown in opposite directions, Fig. 11-13.

Another scheme is shown in Fig. 11-14. This method employs two insulated frogs and the points must have insulated tie rods just as you'd use for a spring switch. The central points will also need insulated rods. Sometimes you can use a fixed frog in place of the movable center points.



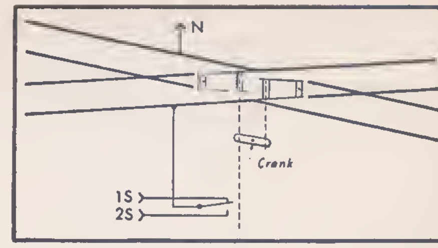
11 - 7 While this scheme requires a more fancy electric switch, it is better suited to multi-train railraading. The drawing shows all wiring needed to keep the frags alive for travel over either route, but this wiring is in addition to the usual wiring for the type af crossing that has insulated frogs as in Fig. 11-2.



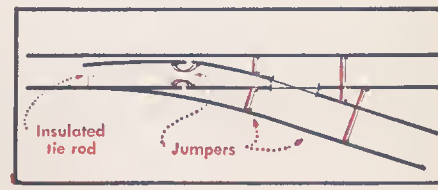
11 - 8 This moving-point crossing for one-troin railroads is the electrical equivalent of two turnauts poin'ing taward each other.

Three-way turnout

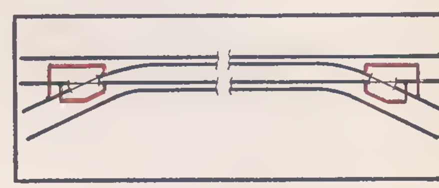
A three-way turnout is just like two ordinary turnouts except that the central frog must be insulated and have jumpers around it. Each set of points can be made in the usual all-metal manner, but the two sets of points and their tie rods must not touch each other when thrown in opposite directions — that's when the turnout is alined for the middle route, Fig. 11-15.



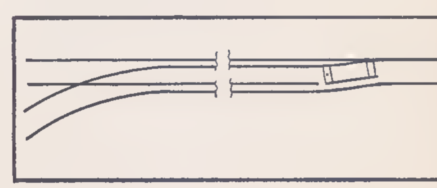
11 - 9 For universal use this arrangement is better than Fig. 11-8. It requires spring contacts like the ones we used in Fig. 8-5. The S feeders from yaur cantral panel do not go directly to the track, but to the contacts instead. This will work only with the common rail type of multi-train wiring which will be explained later on.



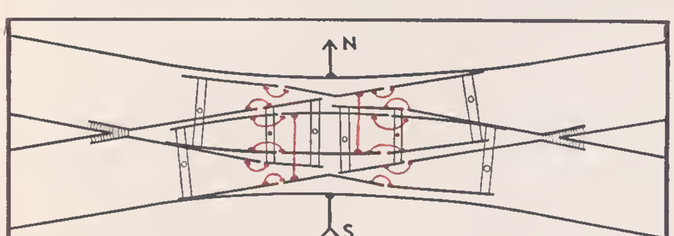
11 - 10 Spring turnouts require insulated tie rods so that electricity cannot pass from one side of the turnaut to the other. Spring turnouts are handy at the end of double track and sometimes an passing tracks, but they tend to make operatian more like a streetcar line than o railroad.



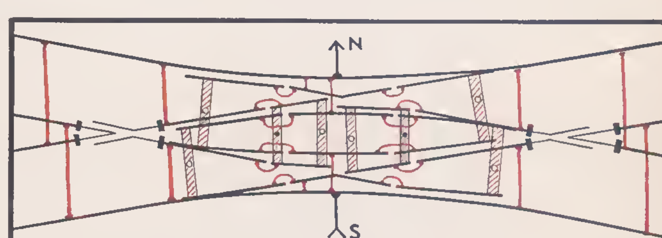
11 - 11 Gantlets between parallel routes require two insulated frogs and four jumper wires. Each 'rack is otherwise considered as independent of the other.



11 - 12 Gantlet turnouts ore wired essentially the same as ordinary turnouts. Gantlet turnouts are used where it wauld be impractical to put the points on a bridge or in a highway crassing, and to avoid putting points on a curve.



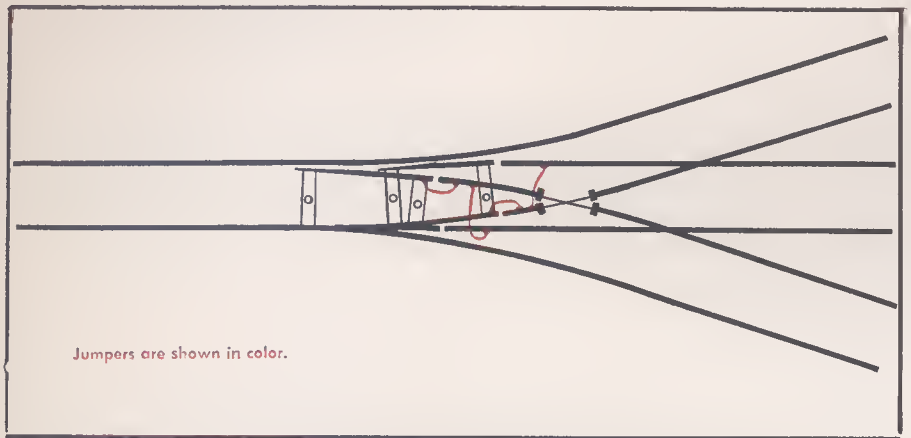
11 - 13 This way to wire a slip switch gives you automatic power routing. The success of its operation depends upon good electrical contoct between the various point rails and the stock rails they move ogoinst. The suggestions on page 24 can be used if necessary.



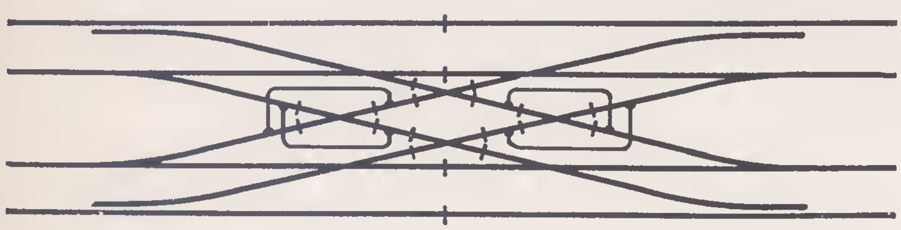
11 - 14 If you feel the scheme in Fig. 11-13 requires too much mechanical equipment, you can use this scheme instead. This requires insulated frogs and also the tie rods between oll points must be insulated. There is no automotic power routing, ond you don't need throw-rod contocts.

Scissors crossovers

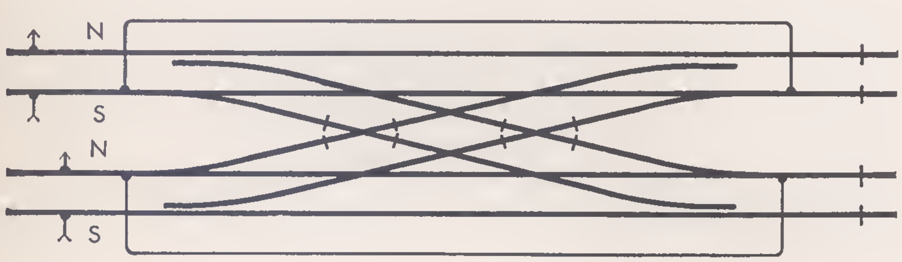
Double crossovers also may be wired in many different ways, all depending on how you handle the crossing in the center. Fig. 11-16 might be called standard, but it isn't the easiest method. Fig. 11-17 will work as long as all turnouts are thrown simultaneously.



11 - 15 The three-way turnout requires one insulated frog and four jumpers.



11 - 16 This is the most frequently used method for wiring a double (scissors) crossover.



11 - 17 Double crossovers wired this way must have all points operated together. Do not locate feeders at the right between the turnouts and gaps except as shown. Follow the usual rules beyond the gaps to see if feeders are needed.

Construction notes

Flexible wire in sizes as small as number 22 can be used for short jumpers and this will be less of an eyesore around complicated trackwork. A dark fabric covering is better than a glossy plastic because it will not catch the light. Long jumpers should be made with size 18 wire.

Gaps in complicated trackwork can be cut with a handy motor tool equipped with a cutting disc or you can use a tapered hacksaw with a small fine-toothed blade.

When you cannot get at a rail in the center of a crossing, cut across all rails including those that do not need gaps. If your rails were firmly spiked, they should not move after you have finished the cut. Now you can fill the unwanted gaps with solder.

A sure-fire way to build fancy crossings is to lay a brass plate on your roadbed and then draw the rail locations on the plate. Screw the plate down in places where the rail will not cover the screws.

When the trackwork is finished, remove the plate and saw all the way through between each pair of rails. When the plate is remounted, the track should be in perfect alinement and all the gapping will be done. The saw cuts made the gaps you need.

Add ties and ballast when the job is done.

Summary

A. The easiest type of crossing to wire is one with two insulated frogs and a pair of feeders.

B. A crossing with four insulated frogs and separate pairs of feeders is better if you plan to run more than one train.

C. Crossings at sharp angles may stall trains. To prevent this, the rails between frogs may be energized. For still better operation the frogs can be energized through a toggle.

D. Spring turnouts and trailing turnouts must have insulated frogs, and the point rails must also be insulated from each other. They do not provide automatic power routing.

Chapter Twelve

Feeders and Installation

This coster-cooster mokes wiring under the roil-road o less bock-breeking tosk. It wos built by Henry Stange ot the Sauth Bend HO club.

IF YOU'VE not already done it, now is the time to complete the wiring marks on your master plan. You can't possibly remember all the things we've talked about, but you have probably made mental notes of the pointers that apply to your particular railroad. I have tried to arrange the material so that you can quickly find anything that has slipped your mind.

Here is a routine that will help when you prepare your plan.

1. Check the plan to see that it shows each turnout and crossing in the proper position with respect to other turnouts.

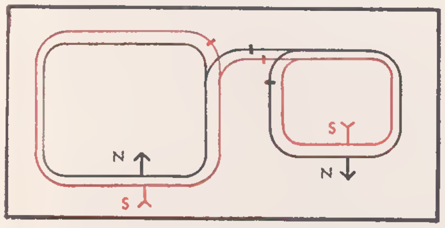
2. Decide how you want to wire any fancy trackwork you might have, as explained in chapter 11.

3. Work out the turning track search and if you find that you have a turning track, plan the isolated section to serve it, chapter 10.

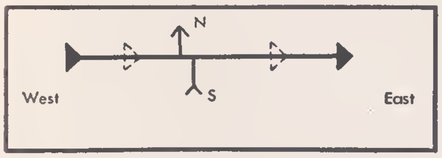
4. Apply the feeder rules. I have collected all rules together on page 43.

5. Now apply the gap rules.

The easiest thing to omit is a feeder connection near gaps that were added to protect a turning track or some special trackwork. Rules 2 and 4 will guard you here. Another easy thing to forget is the pair of gaps between turnouts that point away from each other, rule 7, especially at crossovers.



12-1 The S roil of the moin ovol is outside, os it should be, but the connecting track de-termines thot the S roil of the smoll ovol be inside.



12-2 The speciol routing plon you mode to find turning trocks con be used os o guide for labeling S ond N feeders.

Don't be too concerned if you feel uncertain about the work when you have finished the planning on your master drawing. Even electrical engineers have their troubles with model railroad wiring. If you want to make sure that your wiring plan is correct right now, here's what to do (and it's a lot easier than to try to hunt trouble after the actual wiring is done):

Make a copy of the track on your original master plan, again checking to see if all turnouts are in the right places. Now turn the plan upside down — so that you look at it from an unfamiliar angle — and work the gap and feeder routine over once again.

Check the two plans against each other and if they are alike you probably have everything right.

If you still need help, you can ask an experienced model railroader who is already quite familiar with the wiring rules in *this* book.*

In your plan you have added arrowheads and tails where the rules called for feeders. Now mark all of these with an *S* or an *N*. The feeder *S* should always be on the same side of the track, the "south," or outer side if the route is an oval. The *N* feeders are, of course, at the "north," or inner side.

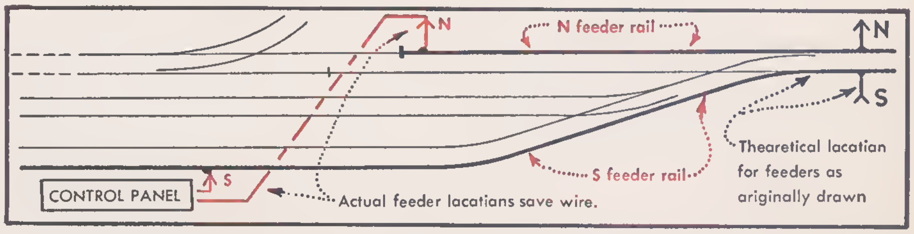
Of course if you have more than one oval route, the most important oval is treated this way and other ovals are tied-in according to how they connect with the main oval. Fig. 12-1 shows how a less important oval might have its *S* feeders inside instead of out. The solid triangles you used in the chapter on finding a turning track can also be used as a guide here. Fig. 12-2 shows the unvarying relationship.

*The reason I am emphatic on this point is that earlier articles by myself and some booklets by other writers have presented different rules for track wiring. The older rules contained flaws which I have tried to eliminate. The old rules should not be mixed with the newer rules in this book.

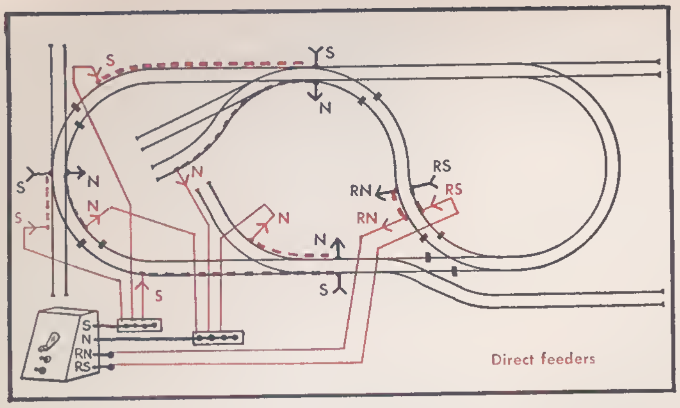
Actual feeder location

The arrowheads representing the *S* and *N* feeders on your track drawing also show where the feeder rails are. The actual feeder wires from the control panel can connect to any part of these feeder rails — not necessarily at the exact place where you drew the *S* and *N* arrowheads. Usually the best place for actual wires is at the end of the feeder rail nearest to the control center.

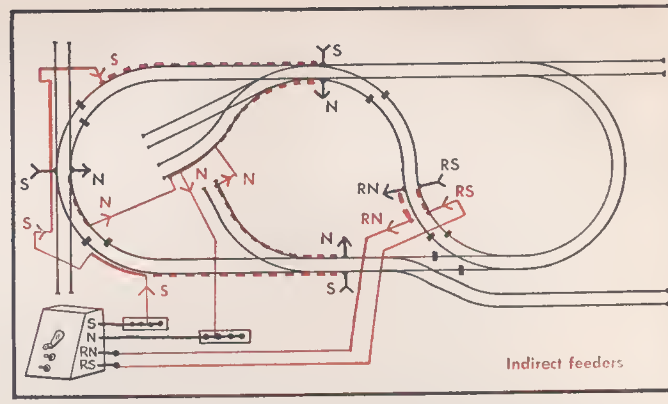
Fig. 12-3 illustrates this idea. Notice that both feeders are moved from the place shown on the drawing and that they are on different branches of the route. This is all right because they are still on the very same rail to which the rules said they should connect.



12-3 The rules will tell us to put o poir of feeders over ot the right af this trock orrongement. I have drown the feeder roils thot extend from these feeder morks with o heovy line. You con connect the octuol feeders onywhere olong the feeder rails. The red lines show octuol feeder connections thot toke odvontoge of this and follow the shortest route from the feeder roil to the control ponel. The N feeder hod to burrow under several yord trocks, but it was still o shorter route. Notice how the N feeder roil stops ot the gop. The trock to the left of this gap is fed from same other feeder system not shown.



12 - 4 The black lines show how a finished wiring diagram might look. The colored lines show actual feeders as installed. Heavy colored dashes along rails show the relation of actual and theoretical feeders for the same block. In this example a separate **S** and **N** feeder is used to supply each feeder rail directly from terminal strips at the controller unit. Terminal strips with one terminal for each feeder make this type of wiring easy.



12 - 5 This type of wiring saves in the length of feeders and is suitable for one-train railroads. Instead of running long feeders to each feeder rail, jumpers connect one feeder rail with another that reaches nearer to the control center. It is essential that the **S** and **N** feeders be kept separate when you do this. This jumper method has many pitfalls and I don't recommend it for beginners. Heavy lines over the rails show how the rails themselves are used as feeders for short distances.

You can move toward either end of a feeder rail in this way, but you must not pass beyond a gap or frog.

It is very important that you keep your *S*'s and *N*'s separated. They don't want anything to do with each other.

You can connect each *S* and each *N* feeder direct to your controller unit if you wish as in Fig. 12-4. This is the best way if you plan two-train operation later on.

Indirect feeders

But if you're going to stick with one train, you can use jumpers for feeders. Fig. 12-5 shows the same track plan and it shows how jumpers can save wire. Notice that the jumper from one *S* feeder rail always connects to the *S* rail in another block. Then this rail becomes a feeder for the more remote track.

RS and RN

If you have a turning track and its associated isolated section, you will have one or more sets of *RS* and *RN* feeders. Treat these in the same way as the *S* and *N* feeders, but connect them to their own separate dp. dt. toggle in the controller unit or power supply. This was illustrated in Fig. 9-7.

When you get ready for two-train operation, your feeder system may be changed slightly but the extra work will be very easy. Even for temporary one-train operation, you connect all *S* feeders together at the main terminal strip and all *N* feeders in the same manner, Fig. 12-4 again.

Rule X

The use of rule X is entirely optional. When you used the other rules they called for gaps at every point where trouble might occur from short circuits. Sometimes the rules are over cautious and ask you to make a gap you could get along without. No harm is done, but rule X shows how to find unnecessary gaps. Sometimes you can omit a feeder, too, when you apply rule X. If you are going to stick with one-train operation, use rule X now. But if you want to run more trains later on or even right away, wait until you know about two-train operation before you use rule X.

X. When the rails at both sides of a gap are always fed from the very same place, the gap may be omitted and the rails at both sides may be fed through the same feeder. See Fig. 12-6.

Auxiliary feeders

Each element in the control circuit has some resistance to the flow of the control and power current. We made use of a variable resistance, the rheostat, to deliberately regulate the current in the circuit. All the other elements also contribute to the regulation, especially when the rheostat is adjusted for full-speed operation.

If we want a full 12 v. of pressure to reach the motor in the locomotive, either we must furnish enough excess pressure at the power pack to overcome the losses in feeders and rails, or else we must design these feeders and rails so that they don't waste too much power.

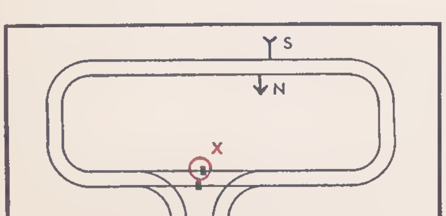
On small railroads we can usually depend on the excess pressure most power packs can produce to overcome the losses. But if we use a power pack that puts out only 12 v., or if we use a battery, there is no excess. Also if our feeders are long or if the track extends for some distance beyond the feeding point, we'll just have to design the feeders and track so they don't waste too much energy. The object is always to get 12 v. pressure to that locomotive when the speed controller is adjusted for full power.

If feeders lose power we just use a larger size. That's why we use size 14 instead of 18 when feeders are long or if the current will be heavy. For very long feeders in O gauge you could use size 12 wire.

But, while you can use larger wire, it isn't practical to use larger rail to keep the voltage drop to a minimum. Wherever the rail alone is inadequate, additional feeders are run parallel to it and they connect at another point down the track to boost the pressure when an engine is running in that vicinity. These are "auxiliary feeders."

A good rule of thumb is to add auxiliary feeders every 10 ft. along a track measured from the point where the main feeders connect, Fig. 12-7.

Our example shows the auxiliary

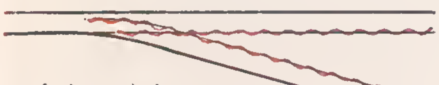


12 - 6 Rule 7 calls for gaps in each rail between any turnouts that point away from each other. Often this is necessary but here's an exception. The rails at both sides of the gap marked **X** get their power through the very same **N** feeder at all times, so that gap can be omitted. Even if the two rails received power from different **N** feeders, the gap could be omitted if those feeders were connected together, perhaps at the control panel end. The other gap cannot be omitted because the rail ends get power from the **S** or **N** feeder at different times, depending on how the turnouts are alined. If you are ever in doubt you can ignore rule X and be perfectly safe. All this rule does is eliminate some work and improve distribution slightly. The so-called "common rail" idea is merely another use of rule X.

ABC's of Track Wiring

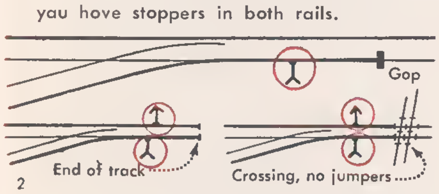
Nine pointers to keep you out of trouble

1. Never lacate a feeder an a rail which leads directly ta or from the frag af a turnaut.
Instead use rule 6 ar relocate the feeder as in rule 2 or 3. For full details an this and other rules see chopter 8.



1

2. Locate feeders wherever a turnaut points taward a stopper.
A stapper is o gap, insulated frog, ar the end of a roil; in short, anything that stops the flow of current farther along the roil. Twa feeders are needed when yau hove stoppers in both rails.

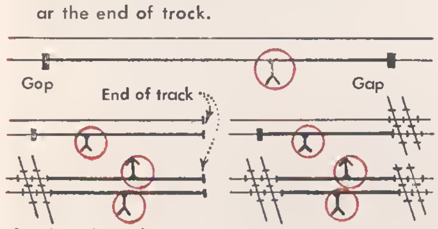


2

3. Lacate feeders in both rails wherever turnouts paint taward each ather.
The turnouts may sometimes be far apart.

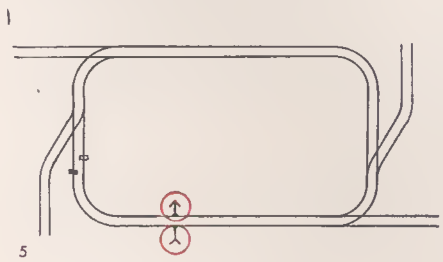

3

4. Lacate a feeder on any rail which runs between two stappers.
Agoin o stopper is a gap, insulated frog, ar the end of trock.



Crossings do not have jumpers.
4

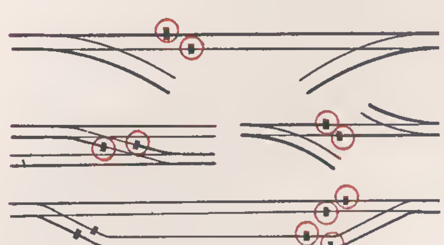
5. Connect feeders to any aval of track that daes not yet have feeders to bath its rails.
After this rule, apply rule 6. This is illustrated an page 26, Fig. 8-16.


5

6. If a feeder must be cannected to a rail which alsa reaches the frag of a turnaut, cut a gap in the rail ta separate the feeder from the frag.
Be sure yau find every place where this rule ond rule 7 apply.


6

7. When turnauts paint away from each other, cut gaps in both rails of the track ar tracks that connect them.
This rule will be used often on most track patterns. The turnouts moy be quite far oport. Don't miss them.


7

8. If yau have a turning track on yaur railraad yau need an isalated sectian where a train can be while you reverse the polarity of the track beyond.

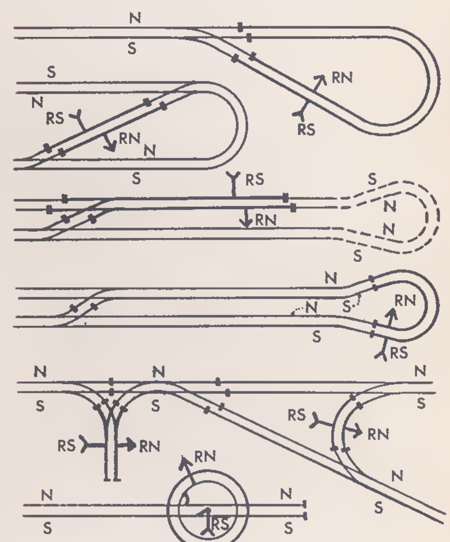
A. This isolated section must be at least as long as the langest train that will use it.

B. Every end af the sectian must have gaps in both rails. (A section that includes turnouts might have mare than twa ends; all need gaps.)

C. The section must have its awn feeders separate from the feeders ta ather parts af the railraad. Mark these feeders **RS** and **RN** ta distinguish them.

D. The **RS** and **RN** feeders shauld ga ta their awn directian cantraller taggle separate from the main direction cantroller.

The sketches show seven of the many woys this rule comes into use. Chopters 9 and 10 go inta detail.


8

Exception

X. When the rails at both sides of any gap are always fed fram the very same place, the gap may be amitted and the rails at both sides may be fed through the same track feeder.

This optionol rule will save you from making an accasianal gap you don't actually need. Use this rule only after you knaw haw you are going to wire yaur cantral panels.

When you're ready for more trains

Track wiring for multi-train railroads requires all the gaps and feeders of the above rules, and additional gaps and feeders are used to divide the railroad into "control blocks." The control in each block is separated so that a train in one block can run at a different speed from trains in other blocks. The idea is to have enough control blocks so that two trains never get into the same block, and here is the rule:

9. Study the train mavements on yaur railraad and then plan black baundaries sa that two trains never get into the same black at the same time. After all baundaries are lacated, put gaps in the **S** rail* near each boundary. Then check with rules 2 and 4 ta lacate the new feeders. All **S** feeders within one block can be connected together.

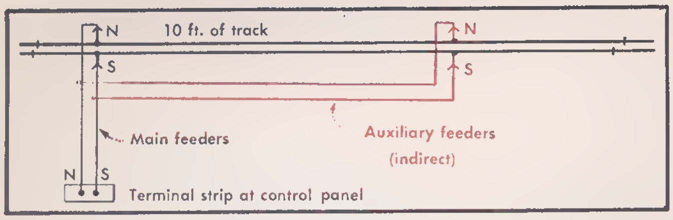
In locating block boundaries, you will find these pointers helpful.

A. Make blocks longer than most trains when possible. Otherwise make them a little over half or a little over one-third this length.

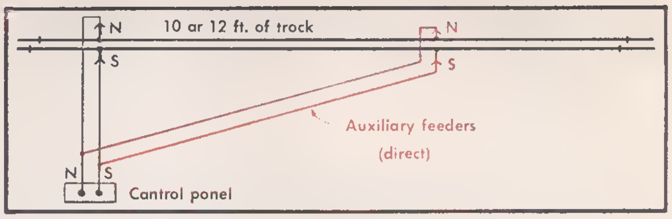
B. Use short blocks where traffic is heavy as at crossings and terminal throats.

C. Not only should there be enough blocks so that two trains never use the same block at the same time; but, on the average, there should be at least one unoccupied block between all moving trains.

*When only one power source is used the N rail must also have gaps at a block boundary.



12-7 Auxiliary feeders help current to flow to the end of long track.



12-8 Here the auxiliaries run directly from control center to the track.

feeders tapping the main feeders at their track ends. You will get better distribution of power if you tap them near the power end, Fig. 12-8.

This scheme might seem to require more wire at first glance, but actually you can space the feeders at greater intervals, say 12 ft., and this helps to make up for the extra wire.

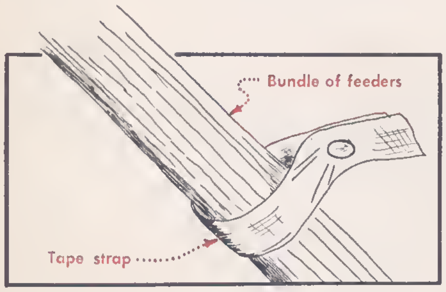
The danger in adding auxiliary feeders is that you might overlook a gap in your track somewhere, and add a feeder to the wrong place. For this reason, and since you don't need auxiliaries except as a refinement, I suggest you put off any extra feeders until after your railroad is in good working order with the regular feeders alone.

Where there are numbers of turnouts it is best not to try to install auxiliary feeders. Instead, divide the track into small compact groups of turnouts and feed each group independently.

Final Installation

THE control circuit will be the same whether you lay your track in sections on the floor or build a permanent right of way, but the way you run the wires may differ.

A floor railroad is at best a temporary thing and very inconvenient for older fellows to operate and maintain. This means the wiring may be of a safe but temporary nature. Your power pack should be self contained in a well-ventilated metal box. It can have the controllers or you can put them in a separate box. The box on page 15 will make a good unit for this kind of railroad.



12-9 A strap of friction tape tacked to the framework will keep feeders in neat groups.

Two wires will run from the power pack to the controller unit and you can use flexible appliance cord for this line. Solder connecting lugs to each end of the cord if the units have screw terminals. If the controller unit has a solder-type terminal strip you can solder the wires at that end of the cord directly to the unit.

Feeders from the controller unit to the track can also be appliance wire. If there is more than one place where feeders must be connected to the track, you will have to be very careful to see that all the *S* feeders are connected together. Appliance wire often has a colored tracer on one of the two conductors that will help you keep this straight.

If you must arrange the wire so that you can disconnect it frequently, buy a small two-prong plug. The plug should be such that you cannot turn the prongs halfway around and push them into the socket the wrong way. Some ordinary house plugs are arranged this way but most are not. These plugs are also rather bulky. Smaller "polarized" plugs with two or many more prongs are sold at some hobby stores and most radio-part dealers. The Jones line is best known but there are other fine makes. You can also use microphone plugs if the contacts aren't too small to handle the current.

Plugs with many prongs are useful on railroads where many feeders must be disconnected.

Flat top railroads

Railroads built on flat boards and ping-pong tables usually have the track laid right on the board. If there is room, the wiring should run underneath these boards and feeders can be connected as we suggested on page 22.

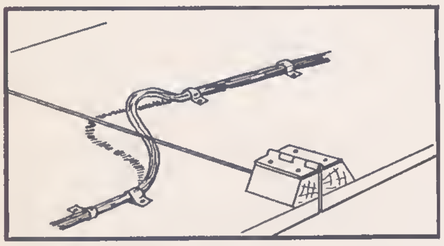
Strap the wires snugly to the underside of the boards with strips of friction tape held by carpet tacks, Fig. 12-9. You could also use staples, but be sure you don't injure the wire. Special staples made for doorbell and telephone work are the easiest to use.

You can use appliance wire or radio hookup wire on this type of railroad. If your power pack is fastened to the board, be sure the 115 v. line is *not* fastened to the board. This would be against most fire protection codes. The 115 v. cord should be loose and go direct to a wall socket without any risky twists or fastenings. Keep the wire up from any damp floors.

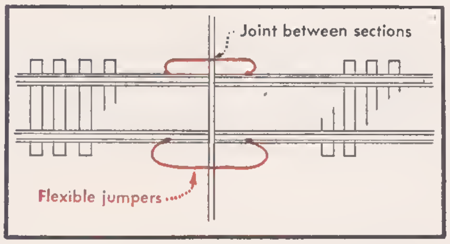
If the power pack is separate, you can use one of the plugs mentioned before to connect it to the feeders.

Portable railroads

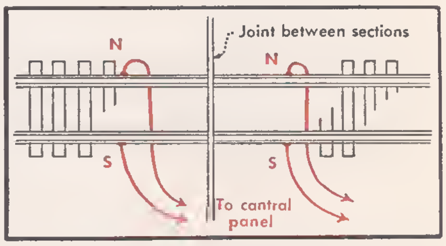
Portables are usually hinged or else come entirely apart. If they come apart you can use plugs to join wires from one section to those from another. At hinges the best way to get the wire across is with a lateral jog



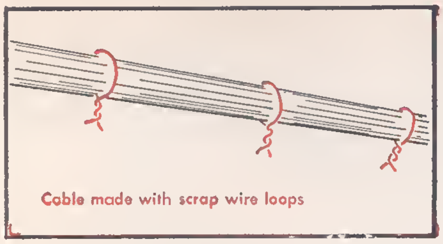
12-10 Bundles of wires should be slack and offset whenever they cross any hinged joint in the framework. This same offset system is used in control panels with hinged panel fronts. Tie the slack portion into a compact cable.



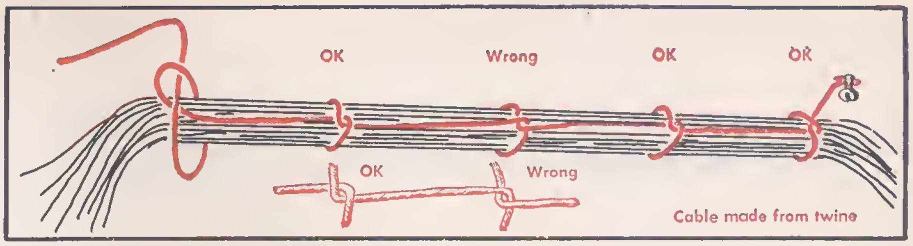
12-11 Flexible jumpers made of stranded wire will feed current across hinged joints in the track. If hinges are not used, a small machine screw terminal will allow you to disconnect the jumpers.



12-12 The idea of running separate feeders directly to the control panel center is better than the jumper methods of Fig. 12-11, because power distribution is more dependable. Use plugs to connect between the tables.



12 - 13 Loops of scrap wire can hold a bundle of feeders in a neat cable. Solid wire makes a better tie than stranded wire for this purpose, but either one may be used. Plastic electrical tape may be wrapped around a cable as another method that is neater but more difficult to open for the addition of more wires later on. For an even better method see Fig. 12-14.



12 - 14 The best way to make a cable is also the fastest one after you get the hang of it. Use strong, hard, wrapping twine or else get cabling twine made especially for this work. Measure out about one and a half times as much twine as the length of feeders to be bundled together and tie one end of the twine to a secure anchor near the beginning of the cable. Make a loop around the cable every 4" or 6". To prevent the twine from loosening as the work progresses, be sure the "knot" is such that the leader runs under the loop. The twine may always be loosened to add one or two extra wires, but usually it is easier to make a second cable. Inside control panels the same technique should be used with the loops spaced more closely together.

and some slack in the wire, Fig. 12-10.

You can bridge the gaps in the rails between each section as in Fig. 12-11, or you can treat each section as a separate track plan and run feeders direct from the control panel as in Fig. 12-12. This second plan is better and easier to install although it may use more wire.

Framed railroads

The usual way to build a model railroad is to construct a grid of lumber a few inches below track level and to support the roadbed and subbase on wide posts. This type of construction is easy to wire, and the best way is to plan routes for groups of wires under the grid. When you have several wires in a group like this, you can hold them in hooks and it is easy to remove any one without disturbing the others. It is also just as easy to add new wires when you need them. Avoid any kind of wire routing in which you have to pull many wires through holes. The work becomes unnecessarily tedious, the wire can be damaged, and you gain nothing.

If wires must leap some distance without any supporting hooks, tie the group together into a cable. This makes the job much neater and is mechanically better, too. You can even make a tied cable turn right-angle bends just like professional switchboard work. Figs. 12-13 and 12-14 show cables.

If you fasten the power supply directly to the framework, be sure you follow local electrical codes. The 115 v. side of the power pack can be fed through metal pipe conduit, and you can install a permanent main switch and circuit breaker for a first class job. Stores which sell electrical fittings to the home owner often have booklets that show just how to install such wiring. Sears Roebuck and Montgomery Ward also carry these books.

Summary

A. Feeders on the outside of an oval or the "south rail" should be labeled with an *S* both on your plan and at the terminals of the actual wire. Mark other feeders with *N*.

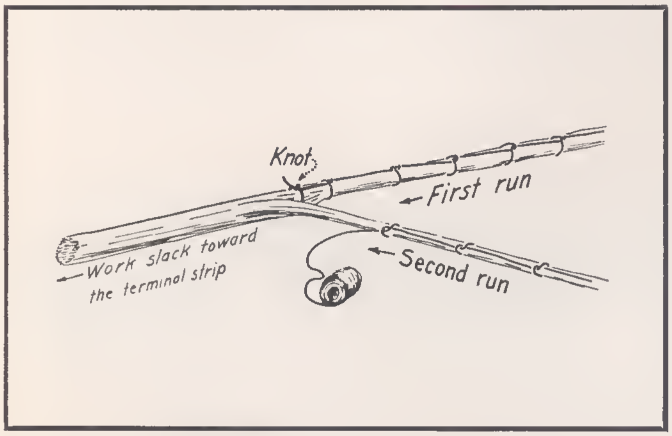
B. A feeder can connect to any place along the rail where the rules say it should go. The limit is the first gap either way.

C. For one-train operation all *S* feeders may be connected together. All *N* feeders make another group.

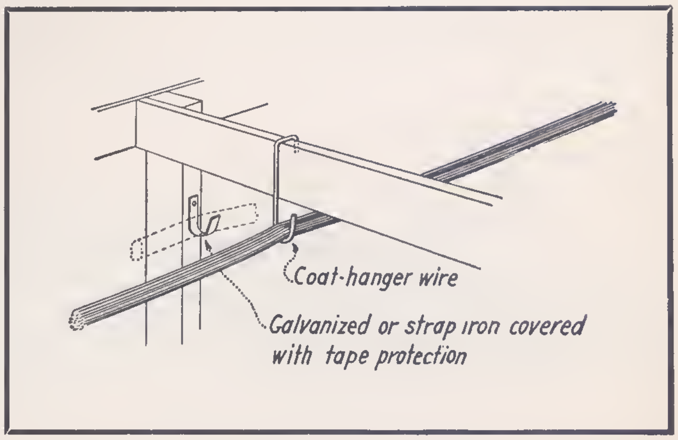
D. Auxiliary feeders overcome some of the losses in brass or steel rail by feeding power at more than one point.

E. Temporary and portable railroads should be wired for convenient re-use. Plugs make convenient connections. Power and control units should be in rugged cases well ventilated.

F. Permanent railroads should have wiring designed with future additions, changes, and maintenance in mind. Power packs can be built in. Electrical codes should be observed in all 115 v. wiring.



12 - 15 This is how you tie the wires where cables join. Work one branch toward the junction and knot it. Then work the second branch.



12 - 16 Hooks can hold a cable of feeders during the time when more and more wires are being added. Later on the group may be tied.

Locomotive Wiring

THE most important thing in locomotive wiring is to make sure the engine runs in the right direction. Put the engine on the track and apply positive potential to the rail at the right, the engineer's side of the cab. This should make the engine go forward.

If the engine goes backward, interchange the connections to the two brushes on the motor. This is easy if each brush is connected with a wire.

Sometimes one brush is grounded to the frame, however, and you will have to find a way to "un-ground" it. In the Lindsay motors you take out a small screw and bend up the lug, Fig. 13-3. Similar schemes are used by other manufacturers. Now ground the opposite brush, connect the wire to the new lug, and the engine should travel forward.

If the motor connections cannot be altered this way, you will then have to reverse the polarity either by turning all trucks around a half turn, or else by reversing all wheels end-for-end in their trucks.

This is the same operation you might perform to correct the next common fault in locomotive wiring, so let's go on.

The first truck on a diesel and the drivers of a steam locomotive should be insulated at the left or fireman's side. Similarly, the tender trucks (or the rear truck of a diesel) should be insulated at the opposite side. See Figs. 13-1 and 13-2 across the bottom of these pages.

Ordinarily the lead and trailing trucks of a steam locomotive are insulated in the same way as the drivers.

Don't forget that when you turn a locomotive on its back you can easily mix up the sides in your mind.

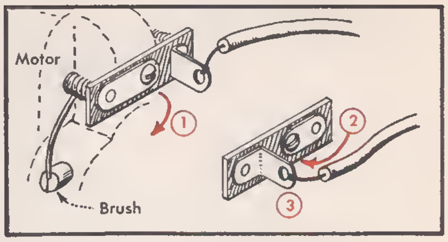
You can detect the insulation in most wheels by looking for the fiber or plastic near the rim or at the axle. If in doubt, see if you can pass electric current from the rim to the truck frame, Fig. 13-4.

In a steam locomotive the tender must be insulated from the engine frame, and a wire from the tender frame goes to one of the motor brushes. The other brush is grounded.

In a diesel one of the motor brushes is connected to the front truck and the other to the rear truck. If only one truck is insulated from the frame, then the frame of the engine may be the connection part way to the motor.

Couplers on both ends of locomotives should be insulated so that you can operate double-headed. This also applies to cars with metal frames.

When a steam engine has no tender, provide small phosphor bronze pickup shoes to rub against the rail or else against the tires of the drivers on the insulated side, Figs. 13-5 and 13-6.



13 - 3 This figure shows how one brush in a Lindsay motor is grounded and how to "unground" it by removing the center screw and bending up, **1.** Now bend the other brush terminal down and replace the screw, **2.** Finally connect the lead wire to the other brush, **3.**

Headlight wiring

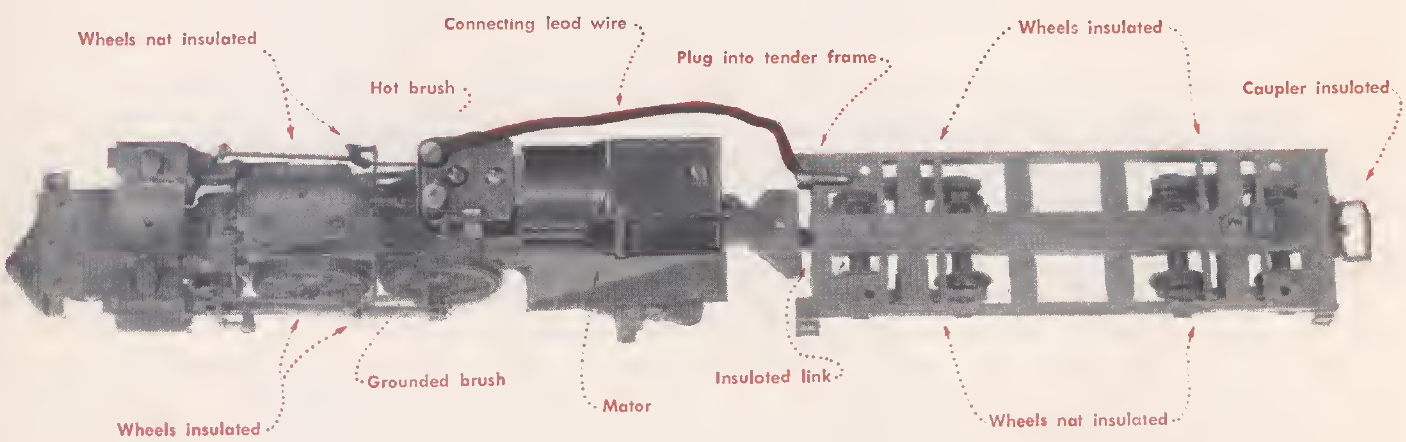
A headlight can be wired by connecting its two wires to the same places from which the motor gets its power. If you want to be fancy, put in some kind of switch so that you can turn the lamp off. A light can also be used in the cab and even in the fire box.

If you prefer to use a 6 v. bulb instead of a 12 v., 14 v., or larger bulb, you can use a number 40 or number 47 lamp in *series* with a 1 w. and 51-ohm resistor.

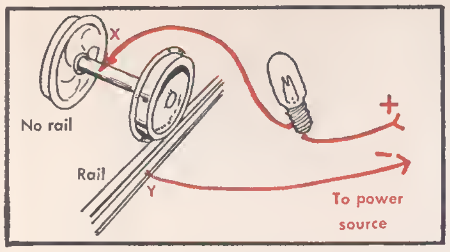
If you want to make the headlight and tender light operate while an engine is standing, you can also arrange a small switch to cut power from the motor.

Universal motors

Not all motors used in scale model railroading are of the permanent magnet type. The universal motor has a coil to produce its magnetic field, and if you want reversing you must have the current pass through this coil in the same direction at all times. Small



13 - 1 We wire steam type locomotives to collect electricity from the right-hand wheels of the engine and to return it through the left wheels of the tender. All other wheels are insulated. Current from the track passes through the engine frame to the grounded brush of the motor. Return current flows through a wire to a connection on the tender frame. Which brush is hot and which grounded depends on how the engine runs. It should run forward when the polarity of the right-hand roil is positive and that of the left rail is negative.



13 - 4 This test shows which end of an axle has the insulated wheel. It can also be used to find defective insulation. Wire X can touch either the axle or the truck frame. If the bulb lights, the wheel touching the rail is not insulated. The lamp bulb should have a voltage as high as the power source used. The source can be A.C. or else your regular power pack.

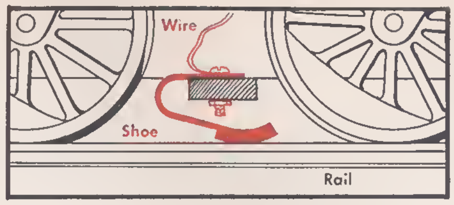
rectifiers especially for this purpose are sold through hobby shops, and they are connected as in Fig. 13-7. You can also use the Travis electro-switch for this.

Motor care

A motor needs very little care unless it is misused. Over-oiling is worse than no lubrication at all because it merely attracts dust and grit to the delicate wearing surfaces. There should be so little oil in the bearings of a motor that none of it shows upon examination. Any oil outside the actual bearing is out of place.

Oil motor bearings about once a month with a toothpick dampened with high-grade sewing machine oil. Don't use combination oils that are also sold as furniture polish. When you use the toothpick, first let all loose oil run off the pick so that there is no wet drop when you reach over and touch the point where the shaft enters the bearing.

If the motor brushes spark noticeably or if the commutator becomes gummy, clean with carbon tetrachloride.



13 - 5 When a locomotive has no trucks or tender to pick up current from the left-hand rail, you can install a spring shoe to ride on the rail. The shoe is made thick where it will wear most. See also Fig. 13-6. Connect the shoe to the hot brush of the motor.

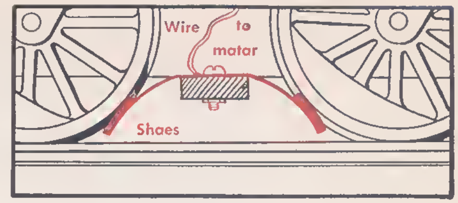
Sometimes a slightly stronger spring tension on the brushes will result in increased motor speed. This means the brushes were not making good contact. Too much tension wastes power and wears the commutator.

The armature of a permanent magnet motor should not be removed for even an instant. Makes of motors which are magnetized after assembly will be weakened instantly by armature removal. Other things that can weaken the magnet are dropping, hammering, or turning on a full 12 v. before the motor starts to turn. This is one reason why it is best to start a train with a rheostat and never with a toggle alone.

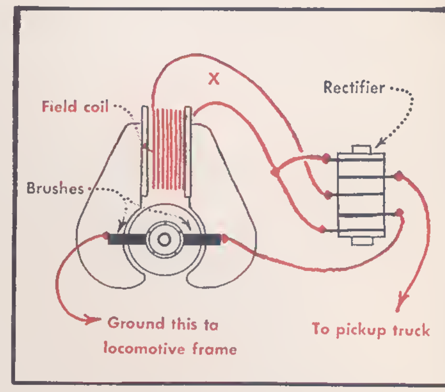
If you pass strong A.C. through the motor it may also weaken the magnet. Weak A.C. when properly used for electronic high-frequency lighting or for signaling will do no harm because the current does not have time to build up a strong magnetic force.

How the motor works

There is one thing I didn't tell you in early chapters and that concerns the magnetic effect of a moving electron. If you force a current of electrons along a wire, their motion will produce a magnetic force around that wire, Fig. 13-8.



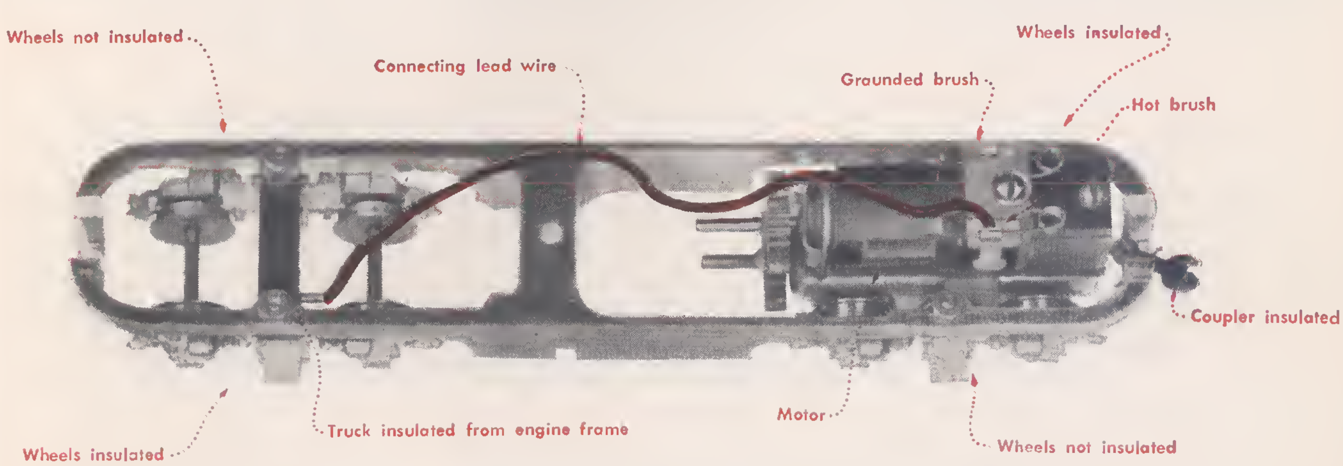
13 - 6 This arrangement is even better because it does not tend to lift the engine off its drivers and thus lose some pulling power. The shading represents insulating material to which the spring shoe is bolted. You can use any other arrangement that will insulate the shoes from the frame of the engine.



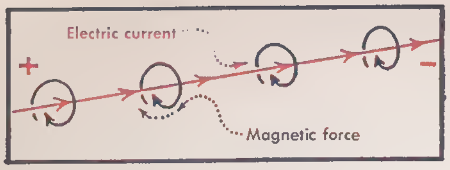
13 - 7 By adding a small rectifier, any A.C.-D.C. or "universal" motor can be made to reverse just like "permag" motors. Notice that the field coil is connected to the middle and outside terminals of the rectifier. If, after assembly, you find the motor runs the locomotive in the wrong direction, interchange the field leads at X.

The force around the single wire isn't very strong unless you increase the current to a value that might melt the wire. But if you put many wires side by side as in a coil, the magnetic forces around each wire in the coil will add to the others and produce a very strong magnetic field, Fig. 13-9.

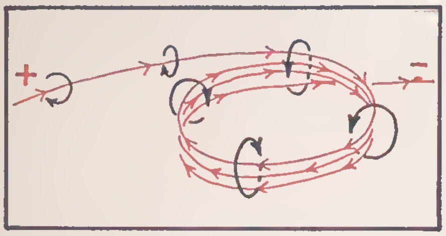
Put a piece of soft iron through the coil and you have an electromagnet that can lift nails or scrap metal, all



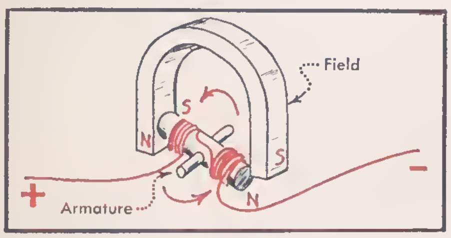
13 - 2 Other motive power uses the two trucks as collectors. Again the forward truck picks up at the right and the other wheels are insulated. One or both trucks must be insulated from the main frame. You can add lights by connecting them across the motor leads. Front and rear couplers should always be insulated from the frame to prevent short circuits when you run double-header trains. In steam locomotives the link between engine and tender should also be insulated. You can install a plug so that the connecting wire can be removed from the truck frame easily.



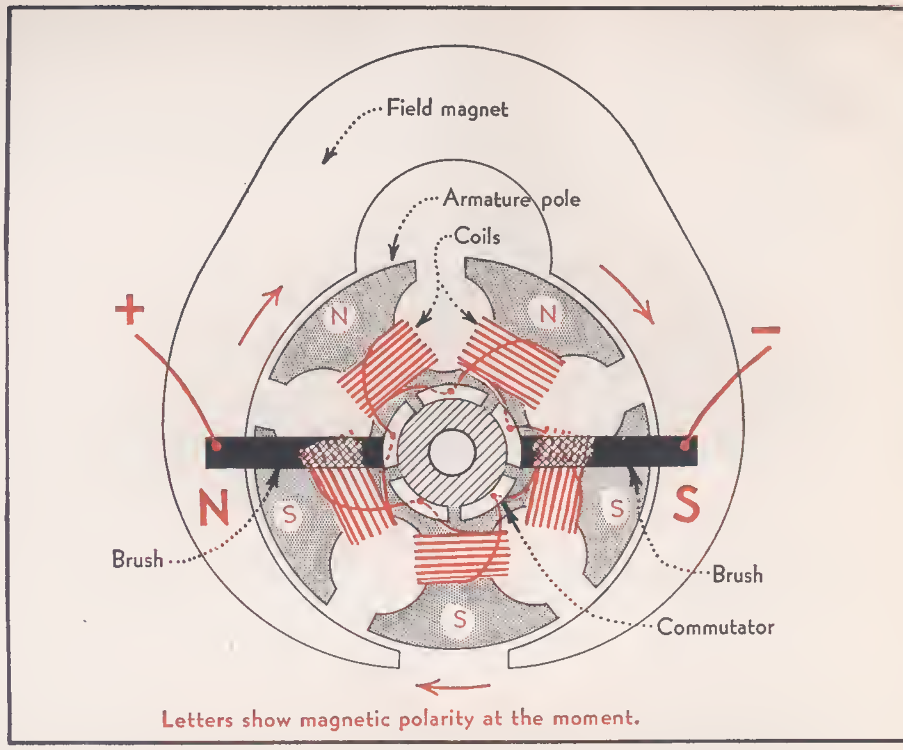
13 - 8 The color shows the path of electrons along a wire. The dark arrows show the magnetic force produced around the current.



13 - 9 If several wires carrying electrons are brought close together, the magnetic effect around each wire complements the force around the others.



13 - 10 If you pivot an electromagnet between the poles of another "field" magnet and force current through the coil, the electromagnet will try to complete a magnetic circuit by bridging the poles of the field magnet.



13 - 11 If you look at the motor in your locomotive you'll find it has a large field magnet and a three, five, seven, or nine "pole" armature magnet. The coils of the armature are joined in a daisy chain and each junction is connected to a segment of the commutator. This motor is shown as viewed from the commutator end. There are five commutator segments in this motor because it happens to have five poles.

depending on the size of the coil, the iron field, and the current flowing through.

This electromagnet is just like a permanent magnet as long as electricity flows through the coil, but it has the advantage of losing its magnetism when you cut the current.*

The magnet will pull or repel any other magnet, electric or permanent, all depending on the relative polarity of the two. Poles are labeled *N* for north and *S* for south.

In an electric motor several magnets are arranged to interact by attracting and repelling each other.

Suppose you mount an electromagnet upon a shaft so that it can turn, and surround it with a horseshoe-shaped permanent magnet, Fig. 13-10. The moving part is called the "armature" and the big magnet is called the "field" in short for field magnet.

If you force an electric current through the coil, the armature becomes a magnet and it will try to move to a position across the poles of the horseshoe. The *N* poles try to approach the *S* poles and the poles of like polarity try to move away from each other so, in all, four forces are at work.

Thus the direction in which the armature turns depends upon which way current flows through the coils.

This flip-flop makes only a half turn and then stops. In a motor a switching device called a "commutator" is added to reverse the connections to the coils each time the armature reaches the crosswise position. Two contacts called "brushes" ride over this commutator. If you look at an actual motor and then study Fig. 13-11, you'll be able to figure out how your motor works.

The current from the brushes reaches the coils in the armature through contact plates called the commutator. As the motor shaft turns, the brushes and commutator act like a direction controller toggle and reverse the polarity of the poles twice in every revolution. This keeps the lower poles trying to move to the left and the upper poles to the right as long as electricity flows in the same direction. To reverse the motor you reverse the electricity and thus the magnetic polarity of each armature pole. This makes them seek the opposite field pole and turn the other way.

Some motors have an electromagnet for the field instead of the permanent magnet. You cannot make the motors turn the other way by merely reversing the electric current because the polarity of the field is reversed at the same time as the armature. That's why we used a rectifier to keep the polarity of the field the same in Fig. 13-7.

Summary

A. Be sure your engines run east when the south rail is positive.

B. The pickup on the forward wheels should be to the right (engineer's side).

C. Couplers should be insulated on all-metal cars and engines.

D. A headlight can be wired across the motor.

E. Universal motors must have a rectifier or polarized relay such as the Travis type if polarized reversing is desired.

F. Use a small amount of high-grade sewing machine oil about once a month on motor bearings. If you can see the oil you have too much.

G. Do not take a permag motor apart, as the field magnet may be intantly weakened.

H. An electric current is always surrounded by a magnetic field.

G. Like magnetic poles repel each other. Opposite poles attract.

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*Permanent magnets are made by using hard steel or special alloys in place of soft iron. They retain magnetism after removal from the coil.

Switch Machines

SOONER or later you will want to operate some of your turnouts electrically. The mechanisms designed for this are called "switch machines" and all of them depend on the magnetic pull of a coil upon a piece of iron called an armature.

In the last chapter I showed that when electricity passes through a wire there is a magnetic pull around the wire, and that if you wind the wire into a coil, the pull is much greater because many turns contribute to the magnetic effect.

Any iron near the coil is attracted toward the coil, and especially to the hole in the center where the magnetic force is most concentrated.

When you stop the electric current, the magnetic force in the coil also stops. A little magnetic force may remain in the iron, but this won't bother us in switch machines.

The important difference in the various types of switch machines is in the mechanical way the coil or coils are arranged to throw the points of the turnout.

The most familiar type of switch machine uses two coils and is sometimes called a "twin-solenoid" machine.

The coils are often flattened so that the machine can be mounted above the baseboard without being too unsightly. An iron armature slides from one coil to the other, depending on which coil has the electric current passing through. The motion of the armature is ½" or more but its power is not very great so a lever or cam is arranged to convert the motion to a shorter stroke with more force.

In the better machines a toggle action or a special cam arrangement makes it difficult or impossible for the switch points to be moved except when the armature itself initiates the motion. This is a protection against false operation due to vibration.

The twin-coil machine is usually more powerful than other types and this is its biggest advantage. Two-coil machines usually take a large amount of power and the coils can overheat quickly. This means you need some special kind of electric switch on the control panel for each machine. The simplest scheme is to use doorbell pushbuttons as in Fig. 14-1. If you use one pushbutton and an sp. dt. toggle you get a more realistic arrangement, Fig. 14-2.

Centralab makes a special toggle that energizes the machine only during the time the toggle is actually being moved, Fig. 14-3. This toggle is better because its position shows which way you last operated the machine. There is an additional sp. dt. contact which can be used to reinforce the power routing around the turnout, or it can be used for indicator lamps. The special toggle is available only from Wm. K. Walthers, Inc., and from a few hobby shops.

Probably the best way to control a two-coil machine is to install cut-off contacts. These are extras with most machines, but are worth the additional four bits or so that they cost. Fig. 14-4 shows the idea. When you throw the simple sp. dt. toggle on your panel, the switch machine operates and then cuts off its own power after the armature has done its work. (It is often better to have the armature operate the cut-off contact rather than to put the contact on the throw rod. This is because the armature keeps on moving for a short time after the turnout has been operated.)

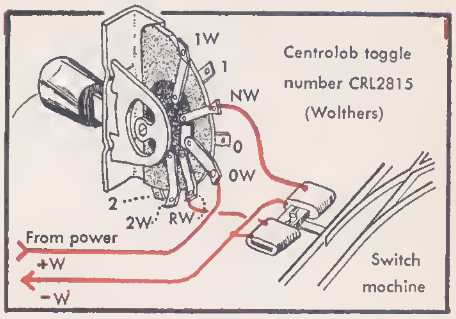
With this arrangement the electric current makes sure the turnout is thrown, a safeguard you do not get with other methods. The toggle on the control panel can, of course, have more contacts for lamps and power routing, or you can put such contacts on the throw rod as we suggested, Fig. 8-5. Since two-coil machines draw a heavy current, all toggles or other contacts you use to control them will have a shorter life than when used to operate single coil machines. All contacts gradually deteriorate due to the arc formed when current is broken. The heavier the current, the shorter the contact life. Silver contacts outlast most other materials.

Two-coil machines should have their own power supply unless you don't mind the jerking effect they produce on your train operation. The power can be 12 v. D.C. or, with some makes, 16 v. A.C. and with plenty of amperes for the short moment of operation. Excess voltage is a help, too.

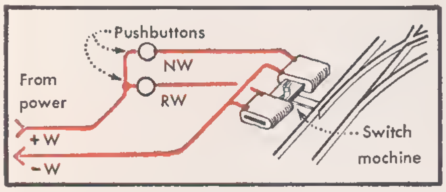
Some switch machines will operate from discarded toy transformers and small power packs. Others, wound with too few turns of wire or with less sensitive construction, may require a fairly husky transformer such as is used for radio filaments or in electric welding work.

Single coil machines

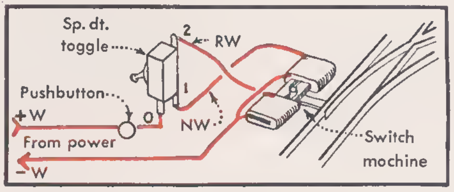
The single coil machines used in



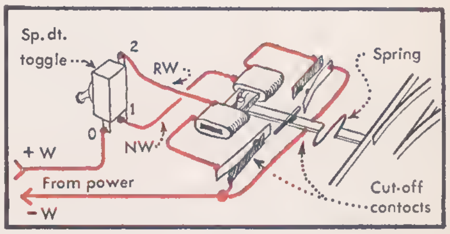
14 - 3 This speciol toggle sends electricity to the switch mochine for a short moment os you move the lever slowly. Contacts 0, 1, ond 2 can be used to power lamps or to reinforce power routing around the turnout.



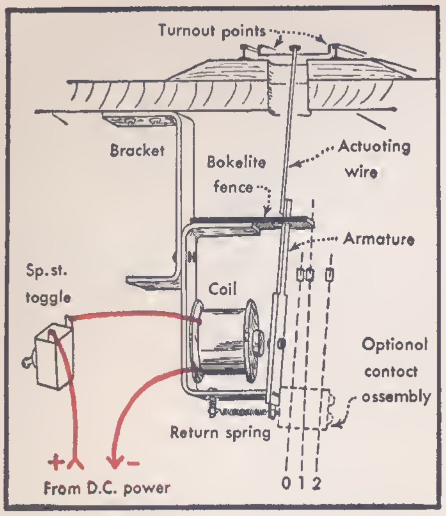
14 - 1 Pushbuttons moke the simplest control for two-coil machines. NW meons Normol sWitch and RW meons Reverse sWitch — roilrood terms.



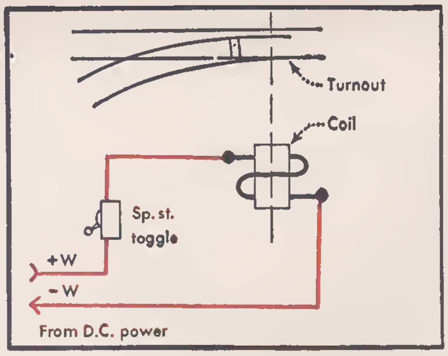
14 - 2 In this scheme the operotor throws the toggle ond then pushes the button long enough to operote the turnout. Some turnout levers on reol roilrood panels work this some way.



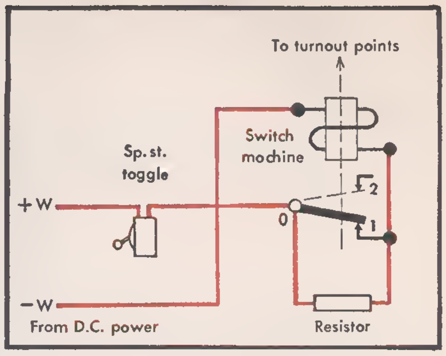
14 - 4 If you add cut-off contacts the operotion of two-coil switch mochines is dependoble ond simple. Eoch poir of contocts is orronged to interrupt the current to its coil as soon os the throw rod hos moved oll the woy over. Note the zigzog spring that ollows some overtravel ofter the turnout hos been thrown.



14-5 The Pioneer Indian Head switch machine is typical of most one-coil machines. This mounting scheme is popular but you may want to modify it to suit conditions on your own railroad. If you add those extra contacts (lower right) for lamps or other uses, do not be confused by the unorthodox arrangement on the Pioneer machine. In this model the whole contact assembly moves with the armature instead of being fixed to the frame. Use the numbers **0**, **1**, and 2, to identify the center, break, and make contacts. Wire leads to the contacts must be very flexible for minimum interference with the operation of the armature.



14-6 Here is the same single coil switch machine of Fig. 14-5, but now it is drawn in schematic symbols. The thin dashes show magnetic and mechanical connection from the coil to whatever it operates; in this case, the turnout points. The turnout is shown in its normal position, and the coil is assumed to be at rest unless marked otherwise just as in any other schematic diagram.



14-7 You can operate many more turnouts from the same power source if you add a pair of "break" contacts and a small resistor to the coil circuit. When the coil operates, the contacts **0** and **1** are separated. This forces all current through the resistor. The resistor wastes about the same amount of power as the coil, so the two together now draw only one half as much current as before. The resistor for the Indian Head machine would be 35 or 39 ohms and 2 w. or more.

model railroading are mostly adaptations of coil operated contacts called relays. When energized, the coil pulls the armature one way. When the current stops, a spring moves the armature back to the normal position. The relay may or may not be equipped with contacts. A lever is added to join its armature to the turnout throw rod, Fig. 14-5.

Most relay types of machines deliver less power than the two-coil designs, but they are usually adequate for HO and other small turnouts. They have their greatest advantage in simplicity of control. Fig. 14-5 shows the way a low-cost sp. st. does the control job. A small amount of electric current passes through the coil all the time the turnout is set for the side track. If a great many machines are used, the arrangement in Fig. 14-7 is an improvement because this latent current is reduced. The resistor value should about equal the resistance of the coil and be able to dissipate 2 w.

If you'd like to add lamps to show which way a turnout is thrown, you can control the lamps with contacts added to the throw rod or to the toggle which controls the machine. Some machines have built-in contacts for this and others offer them as an extra. The same kind of contacts can be used to reinforce power routing around the turnout.

Perhaps the most popular of all switch machines, while they last, are the war surplus rotary relays originally made by Price, Fig. 14-8. These are also one-coil relays but come with built-in contacts to perform every operation you might want. They have additional built-in contacts that reduce the current to a very low value once the turnout is thrown.

Power for single coil machines should be D.C. You can take it from a power pack if the full reserve of the pack is not already in use to run some of your trains.

A single coil machine could be designed to work with A.C., but chances are the hum would be disagreeable. Even D.C. machines sometimes hum and the remedy is to place a 1000 m.f.d. capacitor across the rectifier that supplies them, Fig. 14-9. Well made single coil machines are worth consideration because of their control advantages.

Other switch machines

Other types of switch machines appear from time to time. Scale-Craft once had a dandy one-coil machine that worked on a ratchet principle like the reverse mechanism in a toy locomotive. Other machines have been built like a motor but with only a half-turn movement. Motors with gears or other transmissions make excellent switch machines and some fellows have used discarded furnace regulators. The trouble with many homemade devices is that they take longer to install and often do not do as good a job anyway. Usually your time will be better spent on other parts of your railroad so stick to dependable switch machines that are easy to install.

Installation

I showed you only one switch machine at a time in these wiring diagrams. You can connect as many more as you need to the same power source as long as the source can put out the needed current. Each switch machine will have its own toggle. Of course at a crossover both turnouts always work together so you can control two machines from the same toggle if they do not draw too much current that way.

Whenever you want more than one switch machine to respond to a single toggle, as at crossovers and in yard throats, it is best to wire the machines in "cascade," Fig. 14-12. With this method, power goes to only one coil at a time so there is no excessive current drain. The wiring is shown for two-coil machines. but the principle works with one-coil machines as well.

Contacts like those in Fig. 14-4 or 14-7 are added to each machine, but this time they should be double throw. After a machine has operated, it cuts itself out and deflects the power to the next machine down the line.

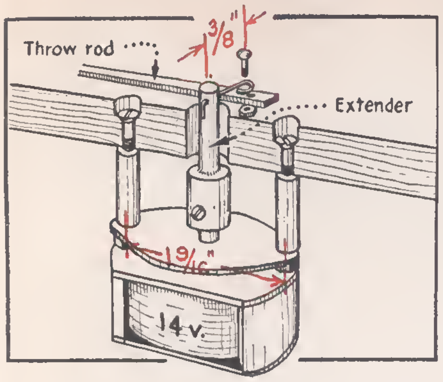
Switch machines can be mounted either atop or below the baseboard, or at the front board of the framework.

The top mounting is easy to adjust, takes few parts, but is an eyesore and collects grit and grease, Fig. 14-1.

Under the table is better but can be tough on you when you work on the machine, Fig. 14-5. The most successful under-table jobs are made in a demountable form so all adjustments can be made before installation.

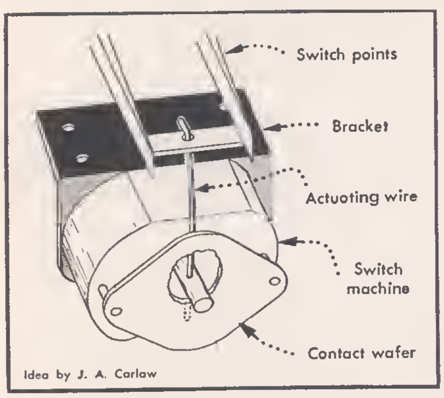
The frontboard mounting is an idea of my own that combines some of the advantages of the other two. This idea can still stand a good amount of development work, Fig. 14-10.

Some switch machines have an adjustable throw and you can make the throw match the actual throw of the switch points plus enough to take up slack in the joints. This method is good only with top mounting as it is likely to get out of adjustment if long rods or shafts are used to transmit the force.

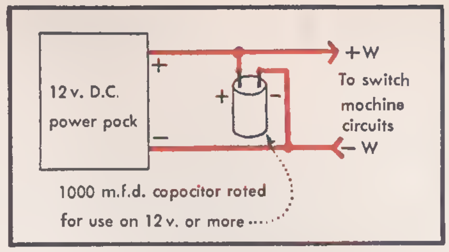


14-8 This is one way to install the rotary type switch machine. The contact wafer must be lowered so that the shaft extender can be attached. See also Fig. 14-11.

It is usually better to have a little give in the throw mechanism and adjust the machine for a little overtravel at each end of the stroke. The give can be a kink in the brass or spring steel throw rod, Fig. 14-4, or, in some designs, you can make the leverage be the spring as in Fig. 14-10.



14-11 Here is another way to install rotary switch machines that works well in almost every situation. Mount the machine on a wood block or metal angle so that its shaft is parallel to the track and directly underneath. The switch point-rod is driven by a steel or brass spring wire that passes through a slot in the roadbed and a hole drilled through the shaft. You may want to add a set screw to keep the wire tight.



14-9 If one-coil switch machines hum, you can reduce the noise by connecting a 1000 m.f.d. (microfarad) capacitor in parallel with the power source. Be sure to connect the plus terminals together. Capacitors are also called condensers. They act something like storage batteries but do not hold as great a charge.

There are also many mechanical ways to operate turnouts but these are not in the realm of wiring.

Towers

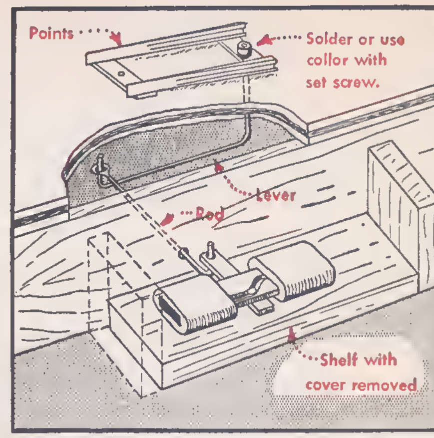
It is logical to call panels which control turnouts and signals "towers." On small railroads you may prefer to put the controls for turnouts on the same panel you use for train control. This is especially good with the map type panel since the toggles that operate the turnouts can be located right where they belong on the diagram.

On larger railroads, and when you have cab control, it is much better to build your towers on separate panels. You can locate these panels where one or more engineers can reach them. Then if you have an extra guest, let him operate the tower exclusively. This flexibility isn't possible if you try to mix all your controls on one panel.

Summary

A. Twin-coil switch machines usually take a heavy current to operate. Their current must be turned off after each use. They are usually powerful.

B. Single coil machines use a small amount of current all the time when set for the side track. They are the easiest to control but must have D.C.



14-10 Wherever there are several turnouts near each other build a shelf at the front of the railroad long enough to hold switch machines for all turnouts. This keeps the machines where they are easy to maintain, and it has many other advantages. The idea works with any kind of switch machine and requires only two moving parts, both made of brass or iron wire. The length of the "lever" controls the amount of throw of the points and it should have overtravel and enough "give" to hold the points firmly against the stock rail. The points themselves can extend in any direction to suit the track, and the lever can be located either to the right or left.

C. Cascade wiring makes it easy to control several switch machines from a single toggle switch, and at the same time prevents more than one coil from drawing power at one time.

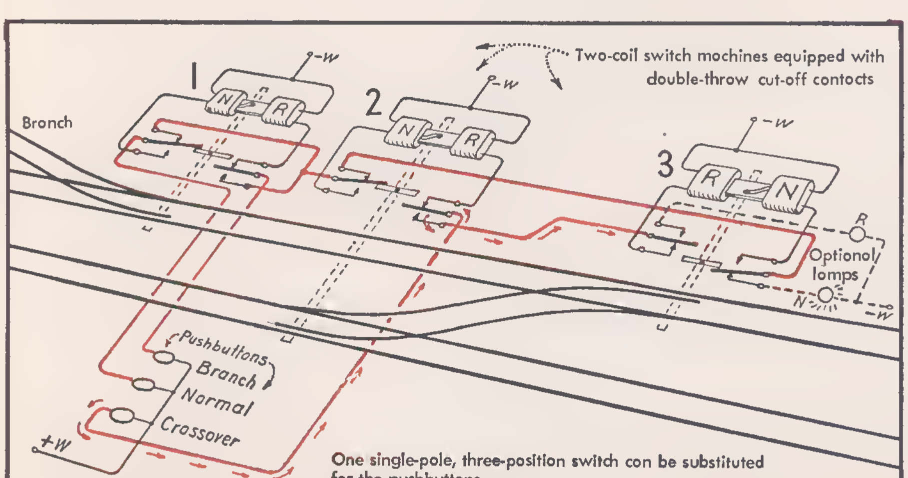
D. Top mounting is convenient but collects dirt and is unsightly.

E. Bottom mounting is hard to get at for adjustment.

F. Frontboard mounting is easier to maintain but requires long rods in some locations.

G. An action with give is easier to keep in good adjustment.

H. Towers are better kept separate from control panels except on one-man railroads.



14-12 Cascade wiring looks complicated until you trace it out. Let's push the button marked "Crossover." This sends plus power along the colored arrows to one of the contacts on switch machine number 2. The contact sends power into the reverse coil and reverses the connecting turnout. This also moves the contact so power can continue to switch machine number 3, still along the arrow path. Now both crossover turnouts are reversed. The other push buttons work the same way for the other two possible routes through this trackwork, and in either case the crossover is restored to normal. Lamps connected according to the dotted lines at the far right will light up whenever a selected route has been completed. This cascade technique saves money on a large pike. Its disadvantage is that you have to install contacts at the turnouts. It's something like prototype NX interlocking.

Finding Troubles

WHEN your train doesn't behave as it should, you must become a sort of sleuth to track down the cause. The method is easy and will locate most troubles in 15 minutes or less. If you happen to have the rare combination of two things wrong at the same time it may take longer.

When you hunt for trouble, be sure you do it very methodically. I once had a "friend" that would guess what the trouble was and then "fix" it. That, of course, gave him two troubles — so he'd guess again. Worst of all, he never learned, and he always swore to his friends that he'd put everything back the way it was in the first place after each false trial. He had the whole model railroad neighborhood avoiding him in two years.

The best way to track down trouble is to make simple tests over and over again while you change just one thing before each succeeding test. The test will give the same answer until you get to where the trouble lies. It is very important that the changes you make while testing are replaced exactly as they were before. A notebook will help you remember what you did.

You need a D.C. ammeter with a scale of about 10 a. or 15 a. These meters cost around five dollars. Don't use an automobile meter because it is designed to read much higher currents and won't be as much help as a more sensitive device.

Also get a socket and lamp of the type used for series Christmas tree lighting. This works on a pressure of about 15 v. but will light up at somewhat less. The leads from the test lamp should be about 5 ft. long and terminated with alligator or crocodile clips as used in radio testing. You can use the same kind of wires and clips for the ammeter, too, but the wires can be only a few inches long. If you built your ammeter into the controller unit panel, so much the more convenient. See Fig. 5-11.

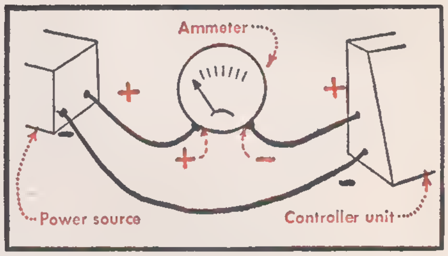
Procedure

A. Determine whether the trouble is an open circuit, a short circuit, or an erratic short circuit before further testing. Test 1 will tell you which of these troubles you have.

B. Open circuits are traced with a test lamp.

C. Short circuits require a more thorough test, and the feeders and other parts of the circuit must be opened and then resoldered during the test.

D. When two troubles occur at the same time, try to separate them. If you don't realize that there are two causes of trouble, the test results may be confusing or inconsistent.



15-1 For these tests you need an ammeter. Disconnect the plus feeder between the power source and controller unit and reconnect so power must flow through the meter. Be sure the plus terminal of the meter connects to the plus terminal of the power source. The minus terminal of the meter connects to the plus terminal of the controller unit and this is not a typographic error. Plus terminals are often connected to minus terminals when devices are in series with each other.

Test 1

Fig. 15-1 shows where to put the ammeter for the first test if you don't have one already in the control panel. Be sure to get the polarities correct.

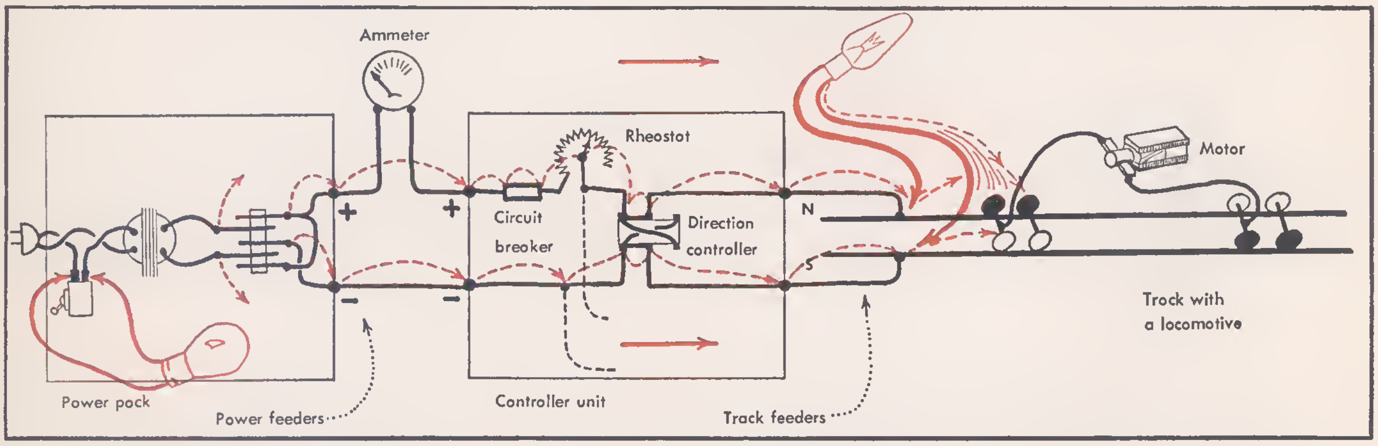
Turn the power on; be sure the circuit breaker is on, also the rheostat and toggles.

If the ammeter gives no reading, go on to test 2. Either you have an open circuit or you're not getting power.

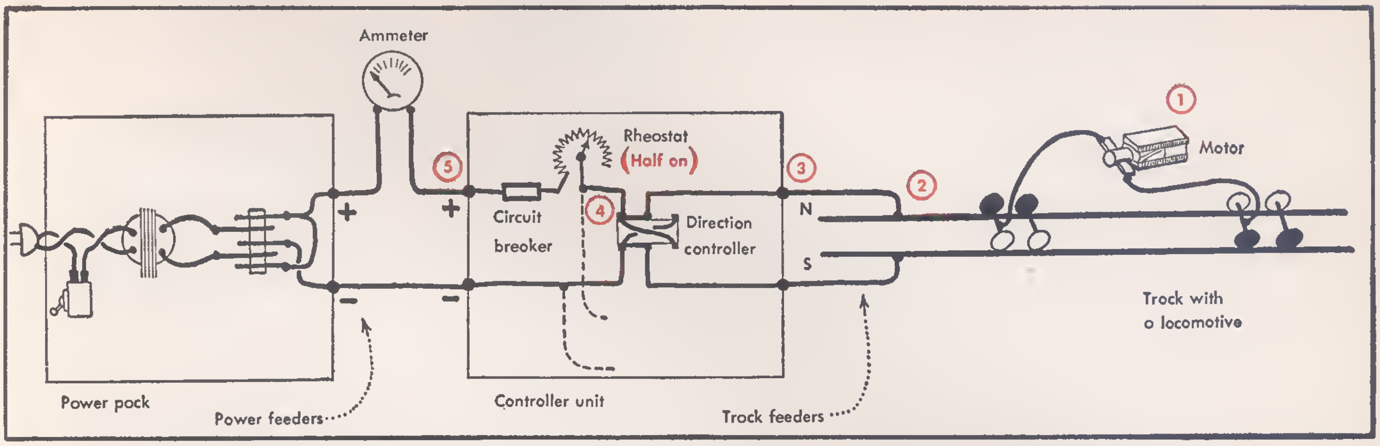
If the ammeter gives a strong reading, you have a short circuit. Go on to test 3.

If the ammeter needle moves violently beyond the usual range when the train reaches certain places in the track, go to test 4. You have an erratic short circuit.

If the ammeter swings to zero while trains run, you have defective connections or dirty wheels. Go to test 5.



15-2 In test 2 the two leads of the test lamp are walked down the circuit while power is on. The lamp will light at each step unless it has passed beyond a defective part where the connection is broken. Keep walking until you find the trouble. It could even be in the locomotive, in which case other engines would still run if placed upon the track. Red bulb at lower left is a 110 v. lamp used to test for defective toggle in the power pack (your regular test lamp would burn out immediately). Don't touch 110 v. wires with bare fingers or metal tools.



15-3 Test 3 is used to locate short circuits. First remove the locomotive, then the car, and then disconnect the feeders, gradually approaching the meter until the meter needle moves to zero. When this happens you have passed by the location of the short circuit. You may have to try this same test from the turning track feeders to the auxiliary direction controller as well. Be sure you reconnect all openings exactly as they were or you'll have more troubles. Usually this test need be made only along the S rail and S feeders. In severe cases even the S rail may have to be cut one or more times to help find the short circuit. I've found short circuits caused by spikes touching inside the ties below a gap.

Test 2

Put the test lamp leads across the power pack terminals. If the lamp does not light, the pack is not delivering power.

If the lamp lights, walk the test lamp outward along the circuit as in Fig. 15-2 until you find a place where the lamp fails. This will be the location of your open circuit. By moving the test leads in smaller steps you can find the exact trouble spot.

If you get power all the way to the locomotive, the trouble must be in the engine. You can use this same procedure to locate the exact cause of trouble in the locomotive, too.

When you make test 2 you will probably find that the cause of the trouble is one of these things:

- 115 v. supply is off.
- Plug is not in the receptacle.
- Cord is defective.
- Power pack is defective.
  - Fuse blown. An overload due to defective parts can blow your house fuse. The fuse or circuit breaker on the pack blows when you have a short circuit in the low-voltage wiring. In this case turn the rheostat barely on, replace fuse, reset circuit breaker, and go to test 3.
  - Transformer burned out. You'd probably know about this without a test. A burnout produces heat and odor.
  - Rectifier short circuited. This will eventually damage the transformer.
  - Rectifier open circuited.
  - Rectifier stale. If you have not used a pack for some time, the rectifier may overheat. It usually cures itself with use.
  - Toggle defective. Test this with a 115 v. lamp. Careful — high voltage. Fig. 15-2 shows the test.
  - Broken wire or connection in pack.
- Break or poor connection in power feeders.
  - Circuit breaker tripped. Reset and go to test 3.
- Faulty controller unit.
  - Poor or broken connection inside.
  - Burned out rheostat.
  - Slider doesn't touch rheostat coil.
  - Burned out toggle.
  - Toggle wired incorrectly.
  - Fuse blown.
- Broken or poor connection in track feeders.
- Poor connection at track.
- Fishplate slipped along rail.
- Bond broken.
- Gap where it shouldn't be. (This one is very common on brand new railroads; perhaps you cut a gap in the wrong rail.)
- Dirty rail.
- Defective locomotive. (Try a different locomotive to make sure.)
  - Wheels dirty.
  - Truck turned wrong way around.
  - Broken connection.
  - Defective pickup shoe.
  - Spring tension too weak at motor brushes.
  - Broken coil in motor.

Test 3

Turn rheostat halfway on. Meter will give small reading. Remove locomotive. If meter returns to zero, trouble is in locomotive. Next remove cars, then feeders at track, then feeder at controller unit. Whenever meter returns to zero you have just passed the part of the circuit where trouble is located. Fig. 15-3 illustrates this test. Resolder all opened connections.

Here are some causes of short circuits:

- Both motor brushes grounded to frame in locomotive.
- Wire in locomotive touches another wire or the frame.
- Coil on motor armature is grounded.
- One axle has been turned end for end in truck assembly.
- One truck turned wrong way around.
- Insulation defective in a wheel.
- Truck frame touches engine frame.
- Coupler is not insulated.
- Gap in rails has closed up.
- Spikes touch under surface of roadbed at each side of a gap.
- Gap was not cut according to rules.
- Feeder connected to a rail that runs directly to frog of switch. (Another common fault on brand new railroads.)
- Metal throw rod of turnout touches a stock rail.
- Feeder connected to wrong side of track.
- Feeders touch where wires are not insulated. Check at terminals.
- Terminal not insulated from metal control box.
- Toggle incorrectly wired.
- Metal object lies on track.

If you have several pairs of feeders, disconnect each pair in turn to see if trouble is in that section of the track. Use block selector toggles for this if you have installed them.

Test 4

Try engine on curves. Truck may be shorting to frame. Cars can do same thing, also couplers.

Try throwing turnouts. A turnout may not be properly wired. Throw rod may touch stock rail.

Wheels of engine or cars may touch points of turnout as they pass over.

Gap at insulated frog may be closed.

Test 5

A connection is loose somewhere. The solder may be broken in a rail joint or frog. See if rail is sensitive to the pressure of your fingers. Look for broken wires. This trouble is often the result of connections that were previously soldered with acid type or paste flux. The joint looks good, but isn't.

Try to get the condition to perform and then use test 2.

Poor operation

Sluggish operation of one locomotive when others run all right is either mechanical binding in the engine or a weak motor. Iron filings in the motor are the worst offenders. A weak magnet can also give poor operation, but this trouble is rare. Dirty commutators or poor spring tension on the motor brushes will cause sparking and poor operation. If the commutator is rough, have it repaired. The brushes can also be so tight that they waste mechanical power.

If trains move sluggishly at first and then warm up in a few minutes, the cause may be oil or oxide coating your wheels and track. This film can be scraped off or else removed with carbon tetrachloride. A *very* light application of clean oil may actually help prevent the scum from forming. Other helps are to run trains at least once a day and to cover the track with cardboard strips to keep dust away.

Beginners' troubles

Almost every model railroader seems to have everything go wrong shortly after building his first railroad. Suppose Mr. Godfrey has completed six or eight cars and a locomotive, and twisted some 35 ft. of track around a corner of his garage or basement. The wiring is finished and a power pack is connected. The long-awaited moment has arrived.

Of course this event is anticlimactic, for Godfrey's engine won't move out of the yard without derailing and there's one spot where the train stalls.

This is the point at which our wonderful hobby loses its appeal for easily discouraged railroaders. The fun seems to be gone forever.

But wait a minute, Mr. Godfrey. That's a pioneer railroad you've just started. Your track crew had no experience. Your car builders were green. Your electricians didn't know a volt from a jolt a few days ago — maybe still don't. It's bad enough when something is built with one inexperienced worker, but you, Mr. Godfrey, are getting your very first introduction to many things at once.

Look at Erv Proudbeam's railroad. It runs beautifully and he was a beginner only a year ago.

So what does it take to sail through the doldrums?

Patience . . .

Sound advice . . .

. . . And a willingness to rip out all the worst part of your work and rebuild to make it the best part.

Patience is something you must learn slowly, and it's the most important ingredient in every skill man knows.

Sound advice comes from people with a wide knowledge of our subject —fellows who can restrain themselves from inflicting their own pet ideas upon everyone else.

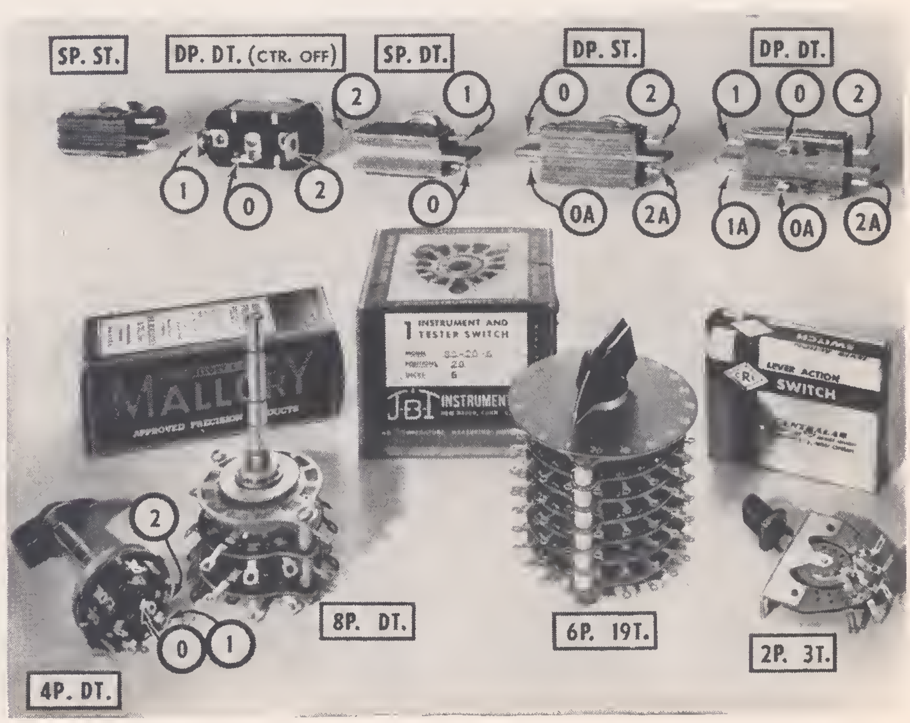
And that "willingness" is just another important kind of patience.

One more pointer on seeking advice — don't collect too much of it. If you ask three fellows you're going to get three answers. What's worse, though each fellow may know a way to help you, the three ideas may not mix at all. For electrical advice find someone who is familiar with the way you wired your railroad, or else take your drawings and this book along so that you can discuss the work on common ground.

And even before you go for advice, why not check your work once more? Maybe your trouble is such a simple thing as a gap or feeder that was put in the right place but on the wrong rail.

Toggle and Wafer Switches

The most used switches for control panels are toggles, upper row. These take a medium amount of panel space and are available at most hobby shops. Often we need more contacts than are available on toggle switches so wafer-type switches, lower row, are beginning to appear in hobby shops. They cost less than the larger sizes of toggles. Also one wafer switch often can replace several toggles. Single-gang switch, lower left, comes in simple contact arrangements such as 6p. dt. or sp. 17t. It is handy for block as well as turnout control. Two samples of "multi-gang" switches are shown. These are similar to the single gang except that they are made up of from one to six decks, each deck having as many contacts as the single gang. Lever-action switch, lower right, is a wafer switch mounted on edge to take less panel space. Its handle is moved up or down like a toggle while gang switches are twisted to left or right with a pointer knob.



Control for Two or More Trains

UP TO this point we have talked about the control of only one train at a time on your pike. Now that you are ready to handle more trains, you'll want to do it realistically but in the simplest acceptable way. This will depend on your own preferences so we're going to talk about more than one way to build your control panel.

You've seen how to make one train go fast or slow with its throttle (rheostat) and run east or west with the direction-control toggle. Now the task is to control one train at one speed while another train follows at another speed or sometimes runs in the opposite direction. Maybe you've thought of some kind of radio-like control that would send a message to each locomotive to tell it what to do. Such "frequency control" is a good field for the experimenter, but the equipment is complicated and so specialized that it makes a hobby all its own. Also, it will probably be a long time before we can do all of the things with frequency control that we now do without it.

Today, the popular methods we use to control several trains at the same time are all alike in one respect: we divide our track into electrically independent segments, called "control blocks."

A control block, Fig. 16-1, is a part of your track with gaps in the *S* rail (or sometimes both rails) at each end. These gaps isolate the block from the rest of the track. The block has its own "control feeder" which is passed through an electric toggle switch on your control panel. If this toggle is turned off, the block is disconnected from your rheostat and power supply so no train can move through the block.

In actual practice, all of the railroad is separated into blocks, as in Fig. 16-2. Since there is a toggle switch for every block you can run trains in some blocks and stop them in others merely by flipping the switches on or off.

The simplest control panels use one toggle for each block, just as we've seen, but in order to run trains at different speeds more toggles are usually added and two or more throttles are also used. After all, you can't run two trains at different relative speeds with only one throttle.

We're going to talk about three basic ways to connect throttles to the blocks. These are:

(1) block control

(2) section control

(3) cab control

Block control is the simplest. Section control is a big improvement because it provides for operating trains at different speeds on *different* parts of the railroad. Cab control is still better because you can operate trains at different speeds on *any* part of the railroad, and thus get operation as much like the prototype as possible.

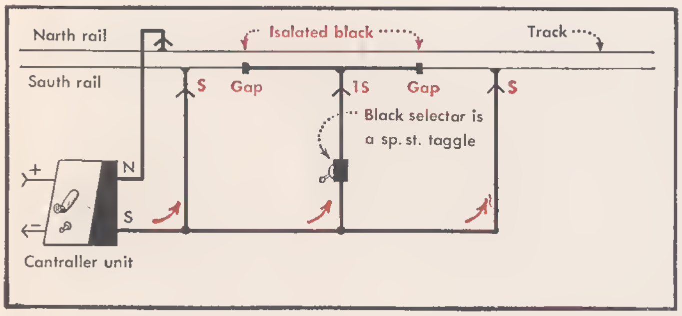
Since a cab control panel can also be used to operate trains by block or section control as well as by cab control, you lose nothing and gain much by building this type of panel. You might ask why we consider block and section control at all then. Well, some railroads can be controlled adequately with block or section control, especially test tracks and railroads for display purposes. Also, learning about block and section control is the easiest way to learn about cab control.

Of all the types of control panel we are going to talk about, the one which is called the "dual-throttle cab" is the best panel for most model railroaders to start with. This is because it will handle two trains perfectly, and more, in a pinch. We'll also see what to do when we want to handle quite a good many trains.

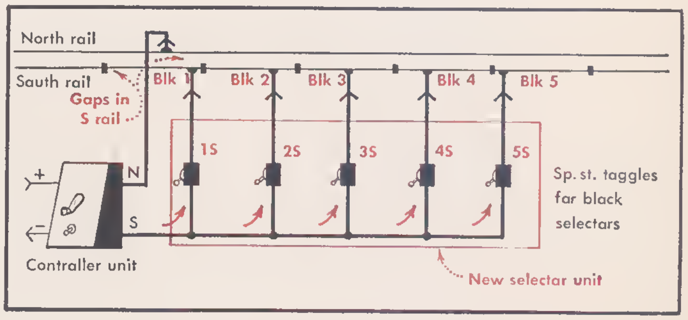
One nice thing about all the control schemes in this book is that the track is wired the same way for any of them with only minor differences at the most. In chapter 18, we'll see how to divide your railroad into control blocks. You'll find your railroad divides into only two kinds of blocks — ordinary blocks and those blocks that are part of a return track, such as on a turntable, loop, wye or return cutoff.

In each of the control panel schemes, the real differences from one scheme to another are in how we connect these two kinds of blocks to the throttles and power packs.

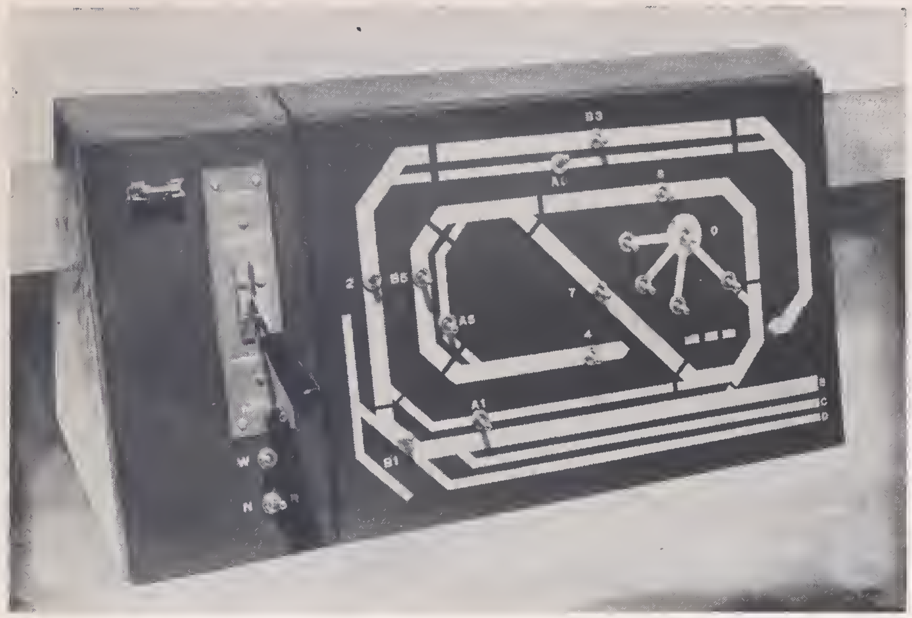
The simplest control schemes use only one throttle for all blocks, no matter how many trains are operated. Obviously you cannot run trains at different speeds with this type of control but you can do quite a bit of railroading just the same. You can stop any train while the others run.



16 - 1 By cutting gaps in the S rail and adding an electric toggle switch, you can isolate one part of your track from the rest of the railroad. Since power can reach this "control block" only by passing through the toggle, you can stop a train here without affecting trains anywhere else. Any kind of electric switch could replace the toggle.



16 - 2 If you divide all the railroad into control blocks, you can stop any train while others run no matter where the trains are. The control panel will have a toggle for each block and it is called a "selector unit." Notice it is usual to put gaps only in one of the two rails to make control blocks although there are exceptions to this.



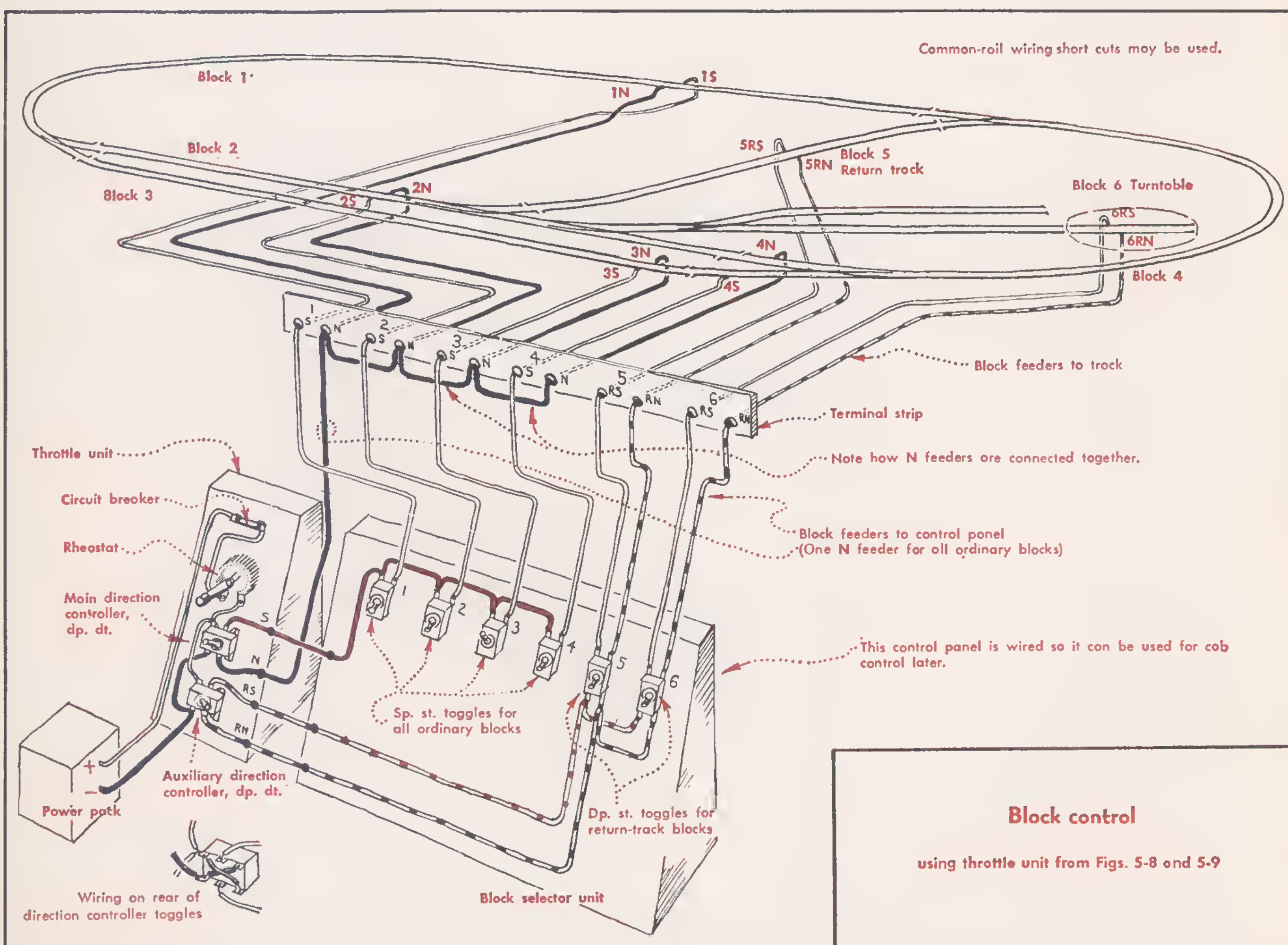
You already know about automatic power routing. We talked about it on page 25. We learned how easy it was to stop a train in one of several branches behind a turnout just by throwing the turnout against this particular branch to cut power. Often you can save the cost of several toggles on your control panel by just such automatic power routing schemes.

Block control

Block control is another one-throttle scheme. If you don't have a turnout convenient to the place where you want to stop a train you can introduce an artificial turnout — a sp. st. toggle switch — just as we did in Fig. 16-1. When you want to stop a train in the isolated block you turn off the toggle. This breaks the circuit to any loco-

16 - 3 The controller or throttle unit, left above, and selector unit at the right make a control panel of the "block control" type. You can see by the positions of the handles that power is turned on (toggles up) for running trains in blocks B1, 2, and A3. All other control blocks are dead. You can also see that trains will move west (W) — which is clockwise — and at nearly full speed judging by the throttle lever. The N and R at the auxiliary direction toggle mean "normal" and "reverse" operation across the turntable or through any return track. Two blocks are too short to hold a train so they don't rate toggles. They are wired the same as on page 76. Toggles for operating switch machines are not shown in this chapter in order to simplify the drawings.

16 - 4 Block control wiring, below, is the same as we saw in Fig. 16-2 but now we have drawn it in three dimensions and added the circuits for turntables and other turning tracks. In these blocks, double-pole toggles are needed to prevent short circuits (via N feeders) that might occur between two panels if you use this type of wiring for cab control later on.



motive in the isolated block but has no effect on other parts of the railroad.

Notice that since you need to break the circuit in only one place to stop current from flowing around it, there is no need to put a toggle in both the *S* and *N* feeders. The toggle could be on the *N* side just as well as the *S* side but breaking on the *S* side of the track is customary.

The control panel in Fig. 16-3 shows what the front of a block control panel might look like. At the left you'll see the familiar controller unit. Of course, this could just as well be a power pack with a throttle built in, and that goes for all of the panels we're going to study. At the right is the "selector unit" which has toggles to select which blocks shall have power and which shall not. The selector unit has a diagram of the entire railroad made large enough so that the handles of the toggles representing each block can be located at the right place on the diagram. You could also put toggles for operating the switch machines on the same panel if the board is made large enough. I left them off only to avoid confusion in our discussion.

Let's see how we run trains with this panel. It's simple enough when you run only one train. Then you flip the power on in all the blocks and run the train with the throttle.

When you want to run more trains with block control the operation is different because you cannot use the throttle to stop one train — that would stop all the others. Suppose you want to stop a train in block 2. You can do this by flipping off the block 2 toggle. This prevents power from reaching that block. If a train hasn't yet reached that block, it will continue until it does and then stop. This is a handy trick to use as it is sort of automatic.

Here's another handy trick you can use when you operate trains with this type of panel. By making sure that there is at least one dead block between any two trains, they cannot possibly collide.

Of course if a train doesn't have good coasting ability, it's going to stop with a jerk when it comes to a dead block or when you snap the toggle off. That is one of the faults of this simple type of control. Another more serious fault of block control is that one train cannot be reversed independently of another because all blocks are controlled with the same direction-control toggle (except in the turning track).

Sometimes block control panels are built using center-off type dp. dt. reversing toggles for each block. These are used as individual direction-control toggles, so trains on different parts of the railroad need not always go in the same direction. A panel of this type is illustrated in the book "A Practical Guide to Model Railroading." It is an immense improvement over ordinary block control but since the panel is so much like the dual-throttle cab that we're going to look at later on, I did not repeat the drawing from the "Practical Guide" here.

Let's see what's inside a block control panel. The track plan in Fig. 16-4 is smaller than the one we've just been looking at since it requires only six block toggles. There are sp. toggles for each of the ordinary blocks and there are dp. toggles for return tracks, such as the turntable and the diagonal return cutoff track across the center of the plan. On a panel for a larger track plan you'd have more toggles for ordinary blocks and perhaps more turning tracks as well, but you'd merely repeat the wiring for each kind of toggle over again. Thus you can adapt this control panel wiring scheme to fit any track plan.

I've shown things spread out to minimize congestion in our drawing. In your actual installation the wires might be cabled; the terminal strip might run in any convenient direction. You might use two terminal strips instead of one as we did on page 19. Perhaps the toggles on your panel might be located on a map instead of in a straight row.

The feeders from both rails of all blocks are connected to terminals on the terminal strip. From here the *S* feeders move on to their respective toggle switches. The other connecting lugs of all these same toggles are connected together by a wire that hops from toggle to toggle and then to the *S* terminal on the throttle unit.

The *N* feeders don't pass through the block toggles, as it is not necessary to open them to cut the power that reaches the trains. Instead, a wire hops from one *N* feeder to the next at the terminal strip and then connects all of these to the *N* terminal at the throttle unit.

Common rail

When all the *N* feeders are connected together like this we call it "common rail" or more correctly, "common power return" wiring. Common connections are used whenever possible in any kind of electrical wiring, as they save a lot of work and money. In our diagram we made the connection between all the *N* feeders common at the terminal strip, the easiest way to keep out of trouble. But in chapter 17 I'll show you how you can interconnect *N* feeders closer to the track and save some wire.

Notice that no part of the *N* feeder system connects directly to the power pack. This is important. For some reason or other, model railroaders often escape notice of this and get into short circuit trouble. The only instances in which the *N* feeder system might be connected directly to a power pack are when you use either twin-power or pulsed-power supply as explained in chapter 17.

The *RS* and *RN* track feeders are connected in much the same way that we connected the *S* feeders except that this time both feeders pass through the toggles. Instead of using sp. toggles, dp. toggles are needed. The reason for this doubled-toggle wiring is to prevent short circuits if you should care to use this same panel for cab control later on (and you can). The toggles for return tracks are connected to the auxiliary direction contoller in your throttle unit. If you're using a power pack with a throttle built in and you have a turntable or other return track, you should add this auxiliary direction controller to the pack. How to do this will be shown in chapter 17.

Toggle and other switches

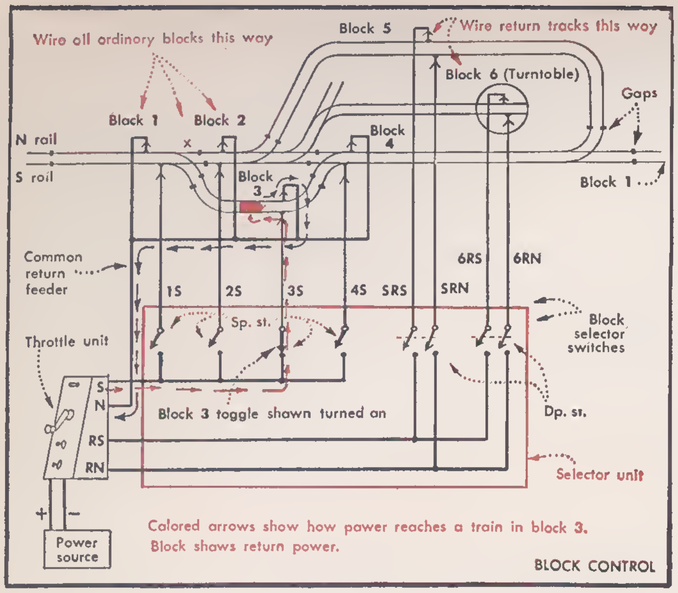
In making up your parts list for your own control panel, buy a sp. st. toggle for each ordinary block and a dp. st. toggle for each return-track block. If you should care to provide for indicator lamps that glow whenever a toggle is turned on, then you need one more pole on each of these toggles — that is, dp. st. and 3p. st. (triple-pole single-throw) types respectively. We'll see how to wire the lamps later on, as there is no connection between the lamp wiring and the control wiring.

It isn't necessary to use toggle switches either. Many other types of electrical switch may be substituted and some have special advantages. The wafer-type switches, illustrated on page 54, are among the best for model-railroad use and should be better known than they are. They come in many contact combinations and are often cheaper to use.

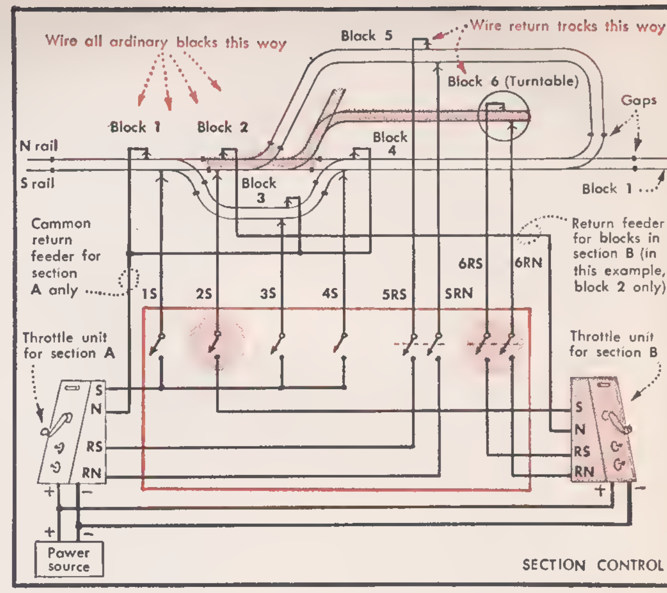
In making the substitution of one kind of switch for another, just be sure the switch will carry one ampere or more of current and that it has enough poles and enough throws (or positions). Too many poles and too many positions won't hurt a bit. For instance, you can substitute a three-pole four-position switch if a two-pole three-position is called for.

I drew the control panel in Fig. 16-4 in 3-D, but you can save time by making your own drawing in schematic form as in Fig. 16-5.

This illustrates still another trick



16 - 5 Block control looks like this when drawn in schematic form. Notice how closing any toggle closes a circuit (colored arrows) to the track.



16 - 6 In section control you combine groups of blocks into sections. Each section is wired like block control. For cab control, see page 61.

of the craft — that of unwrapping a track plan. The track plan in these diagrams is the same as in the 3-D drawing but I've unhooked it at the back and unfolded the two end curves so the whole oval is represented by a straight line. This technique is handy for planning operations as well as wiring.

Section control

With block control any train can be stopped but all the moving trains must go at the same relative speed and in the same direction because they share only one throttle unit. Why not use more throttle units? That's just what model railroaders did years ago when they created "section control." The idea was to control part of a railroad from one throttle and another part from a different throttle. Sometimes they call this "division control."

Fig. 16-7 shows how a two-throttle section control panel might look. In actual practice three or more throttles are usually required and in general there should be more throttles than there will be trains. All of the blocks indicated on the panel with a white line are controlled from throttle A while the blocks indicated with a gray line are operated from throttle B.

Let's see how you run the trains. If you have only one train on the railroad, then you turn on all of the block toggles you'll need and operate with the two throttles. You use the A throttle part of the time and the B throttle the rest of the time, depending on which section of your train is in at the moment. When you run two trains, how you operate them depends on where the trains are. If one train is in one section and the other train in another, you can run each train with the throttle for its section. You can also reverse either train without affecting the other. But when two trains get into the *same* section, you're in trouble. When this happens, you're no better off than you were when you used block control because both trains must then be operated from the same throttle and direction switch. From this you might think the ideal would be to have a separate throttle for every block. Then you could run a train at any speed in any block regardless of the speed of other trains in other blocks. The cost of this would be very high so a compromise is usually made by using fewer throttles.

But even if you could afford this ideal, section control still has some faults. As the train runs along the railroad you must move your hand from one throttle to another to keep the train rolling at the desired speed. This is often quite awkward. If you adjust the throttle too high or too low, the train may jerk to a new speed as it enters the new section. The jerk is even worse when two trains are in the same section. If you stop one of them, less power is drawn through the rheostat and the other train shoots ahead. Likewise, as a train moves from one section into another, there is a point where it is powered through two throttles at the same time. This also causes a lunging ahead, especially at slower speeds.

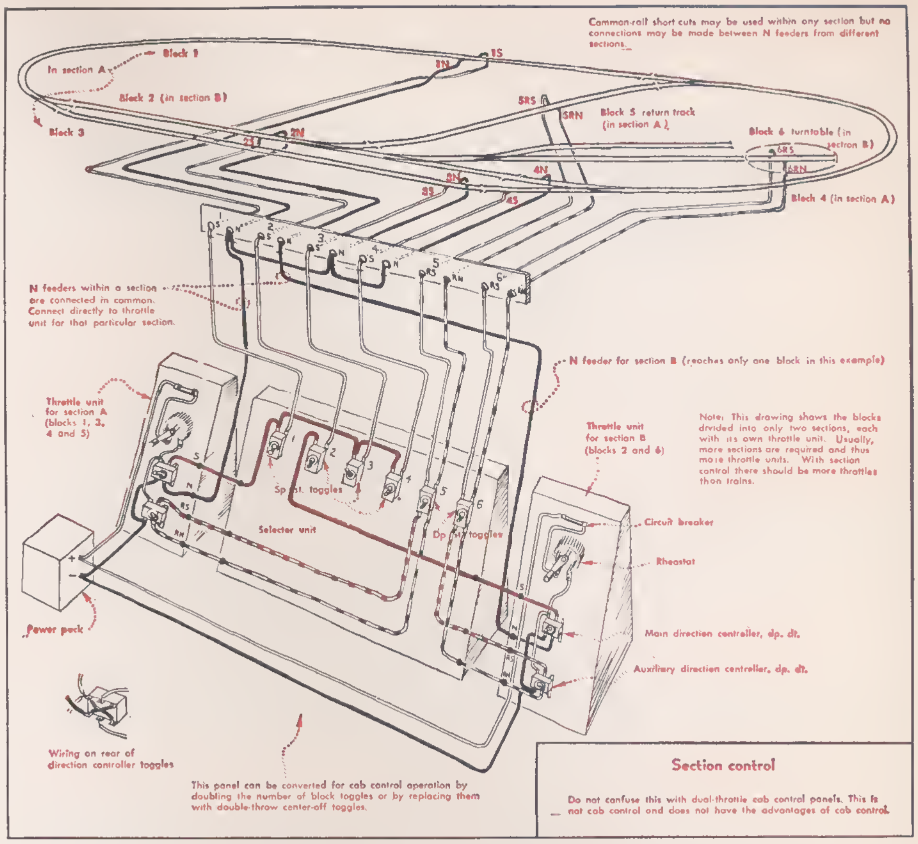
Section control is good for display railroads and it is even used success-

16 - 7 Divide your track into groups of blocks, give each group its own throttle, and you have section control. This board has a gray and a white group; usually there are more than two.

fully on some club systems where plenty of manpower is always on hand. It is most practical for the two-track oval where you don't plan to let the two trains get onto the same oval at the same time.

But because section control usually costs about as much as cab control (sometimes quite a bit more) and because operation with it is less realistic, I do not recommend it for model railroaders except where careful study shows some unique advantage for a particular railroad.

Section control panels are wired in somewhat the same way as we did for block control, but instead of having all the toggles connected to the same throttle, some are grouped and connected through one throttle while others are connected through another, Figs. 16-6 and 16-8. As mentioned before, in most cases there will be three or more such groups, each with a separate throttle unit. The toggles and throttle units within each section are wired the same as for block control. Even the *N* feeders within a section can be connected in common, but there must be no connections between any of the feeders in one section and those in another. For this reason there must be gaps in *both* rails at the boundaries between sections.



16 - 8 Sections are wired the same as for block control but there must be no connection between N feeders of one section and any other. Two trains in the same section will go the same speed.

Cab control

The big difference between cab control and the other kinds of control is in how you run the trains. A panel designed for cab control can still run trains by block control and it can still run them by section control, so there is no need to review these methods. But the cab control can also be used to handle trains by cab control methods.

The idea is to run a train from the same throttle no matter what part of the track it is running on. Since each train is run from its own throttle there is no need to adjust a throttle to the needs of first one train and then another. The controls for one train are called a "cab." They consist of a controller unit and some toggles or other electrical switches to connect the throttle to any of the blocks the train will use. Since these particular controls are associated with the same train throughout its run it is a lot more like operating from the cab of a real locomotive.

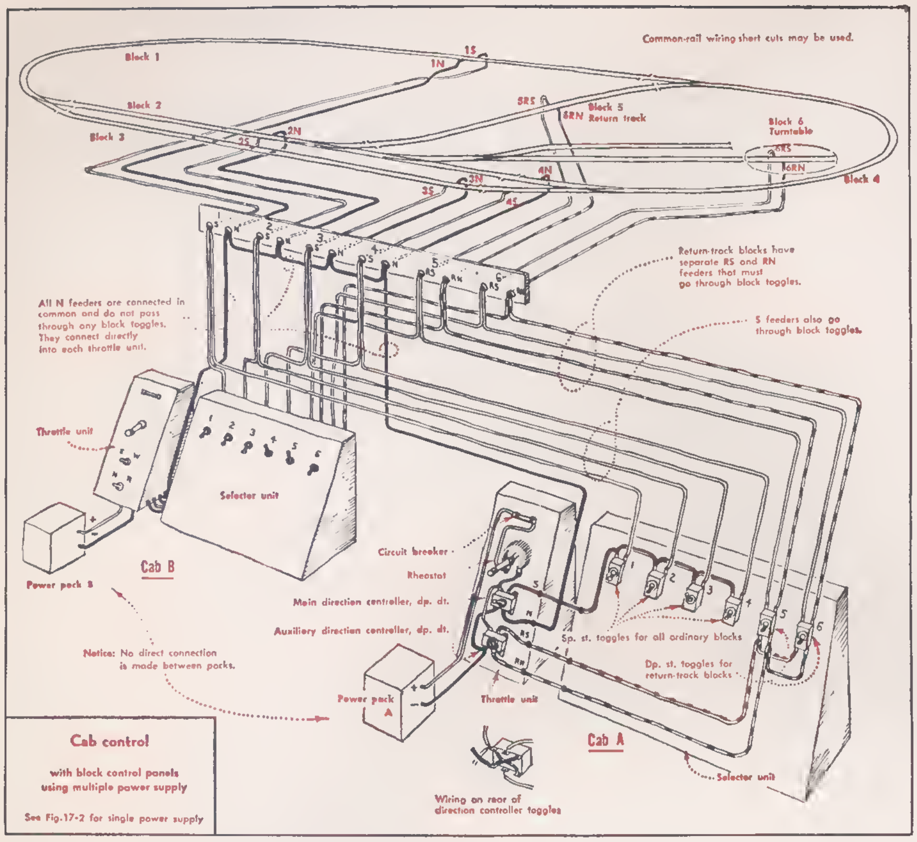
You can put the cabs for handling several trains on one big control panel, but if you are going to have guest engineers at times, it is better to have at least some of the cabs on panels located away from the main panel so operators can have more elbow room. A good plan is to start with a two-throttle main panel, the dual-throttle cab we'll soon be investigating. Then, if your railroad grows, you add separate one-throttle cabs for the added trains.

It may seem like a big order to build two or three control panels instead of only one but the amount of electrical equipment you use will be no more than if you were to build one super-panel to handle all the trains. Yet with the same parts now spread over several panels, you'll find it easier to operate.

Here's another important advantage. By building separate small panels, you can build your system a panel at a time. As you add more cars and locomotives, you also add more panels. Actually you may not need as many cabs as you have trains, however, because as soon as one train finishes its run, its cab can be used to pilot another train. You need only one cab for each train that will be running in "rush hour."

The wiring in one cab has no effect on other cabs, so there is nothing to be changed or salvaged as you add a panel. Likewise you can add a cab control panel to your present railroad even though it is already wired for some other kind of control and you can do this without having to sacrifice the use of the original panel. This is a big help on both home layouts

16 - 9 and 16 - 10 If you add a second block control panel, just like the first, you can use the two panels to run the railroad by any desired method — block control, section control, or cab control. When operating by cab control, the panels are called "cabs" and each cab is used to run only one train. The toggles are kept off except for the one or two blocks the train is actually using or about to use. You can add a cab control panel to any model railroad to get better operation without impairing the usefulness of any panel already installed.



16 - 11 If you provide a block control type panel for each train, you can operate a railroad by cab control. The wiring in each cab is exactly the same as in the block control panel of Fig. 16-4. While we show two separate power packs here, you can modify the wiring in the panels so one pack will supply both cabs. We'll see how to do this in chapter 17.

and club layouts already wired for section control but outgrowing it.

In Figs. 16-9 and 16-10 I've shown two plain-type cabs. Normally you run one train with the left-hand panel and another with the right. You can handle both panels yourself, if they're not too far apart, but when you have a guest it is even more fun. You'll operate your train with your cab, no matter where the train goes. It's like running a real engine and you are the engineer. The other fellow operates his train from his cab.

On your panel there are enough toggle switches so you can connect the throttle to any block or combination of blocks your train will run through. You turn the toggle on just before your train reaches each new block. You also turn the power off from the blocks behind your train. This is important. If you should accidentally forget to throw the toggle off behind your train and the other fellow should connect into the same block, you would have what is called a "feedback." This will connect both trains to both throttles, an embarrassing situation that usually happens only once and then an engineer remembers his toggles thereafter. There are ways to guard against feedbacks which we will talk about later.

When you operate, the toggles are not used to start and stop your trains. Since your throttle is connected to only your own train, you use it for all starts and stops and the operation can be as smooth as in the prototype.

Cab control is loads of fun if your railroad is large enough so that you can accommodate several guests. One or two guests can operate the turnouts and the rest will take cabs to run the trains. At first, everyone will feel clumsy but before long your group will be doing some mighty fancy railroading. You'll be handling mainline trains at speed, way freights setting off cars at industrial sidings, yard switching and even such operations as adding a pusher engine to help a long freight up a hill. There is no end to what you can do because now each man's attention is on running a locomotive. With section control he was more likely to be hunting for the next throttle handle.

Cab control panels are also easy to use when you're railroading by yourself. At first it is best to operate by block or section control methods. But this doesn't mean that the cab control isn't an improvement over block control or section control panels. You see, now you can change the boundaries between the sections any time you like and thus adapt the controls to the needs of the trains. You turn one group of toggles on in one cab and all of the rest of the toggles on in another. This divides your railroad into two sections. When you want to change the boundaries of the sections you just move some blocks from one panel over to the other by flipping the toggles. After some practice you can also develop the skill of running two or even three trains by regular cab control methods.

The two cabs in our diagram are of the type called "plain cabs" or "block toggle cabs." They are wired exactly the same as for block control but now because we have two panels instead of only one, the operation of trains is much better.

Cab control wiring

If you compare Fig. 16-11 with the diagram for block control, Fig. 16-4, you'll see that with plain cab control we've merely repeated the original block control wiring a second time. Both panels are connected to the same terminal strip so there is no change in the track wiring. You can add *any number of cabs* to the terminal strip in this way.

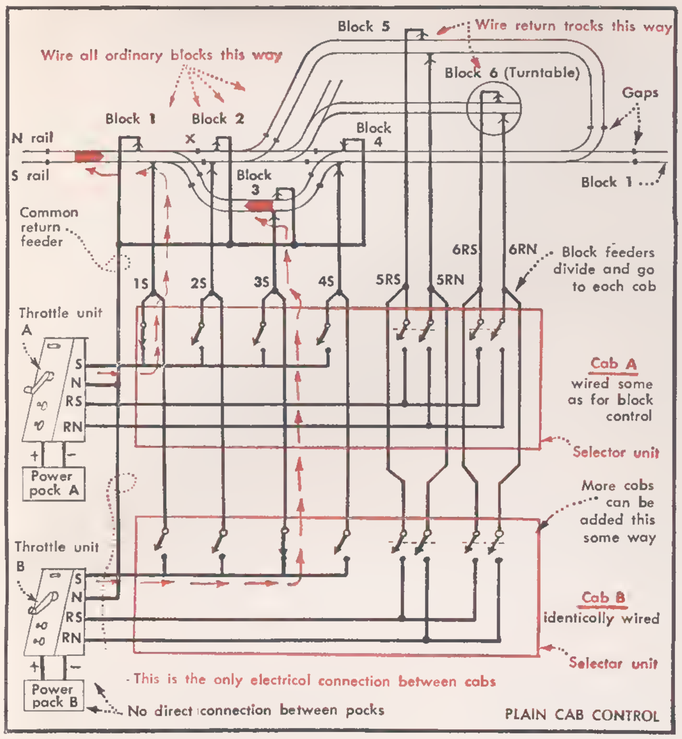
By studying Fig. 16-12 you'll see how power from one throttle will reach a train in block 1 while the other cab can power a train in block 3. The only connection at all between the two circuits to these two trains is through the *N* feeders and since this is only a single wire connection, it cannot cause any short circuit or any other interference between these two cabs and their two trains.

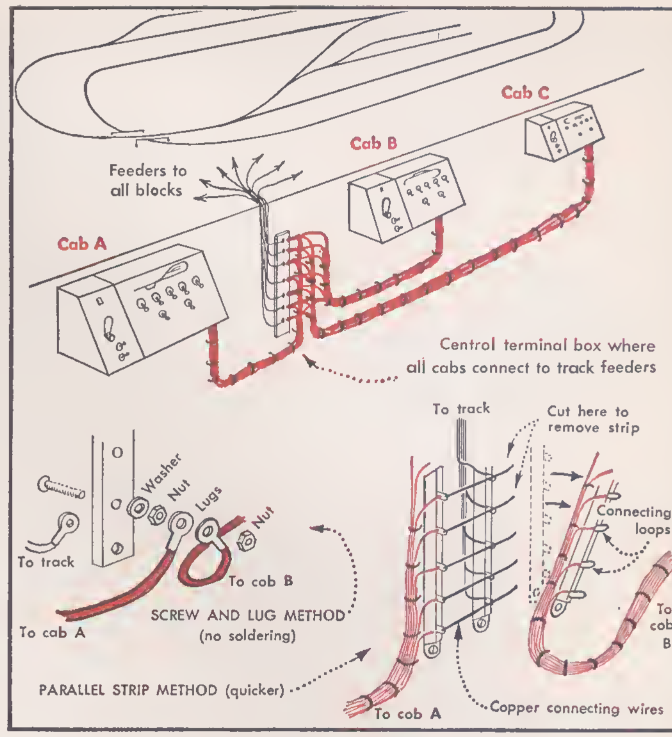
Our diagram shows both cabs taking their power from two separate power packs, but it is possible to modify the cabs so they can share the same power pack. I'll tell about this in chapter 17. It has both advantages and disadvantages.

It is easy enough to draw many cabs connected to the same terminal strip, but in practice, there's a limit to the number of wires that can be connected to a single terminal. Some ideas along this line are shown in Fig. 16-13.

It may bother you to see that the plus terminal of one power pack can be switched through the direction-controller toggle to the *N* feeders, while at the same time the minus terminal of another power pack is connected there. This does not cause any short circuit. The batteries in a flashlight are arranged with the plus of one battery touching the minus of the next in the same way and there is no short circuit there either. There is no short circuit in either case because there is no circuit loop at all.

The only way you can have a short





16 - 12 We saw in Fig. 16-6 that section control was merely a repetition of block control applied to groups of blocks with no overlapping between groups. Cab control is also a repetition of block control, but each panel has toggles for many or all of the same blocks. The colored arrows show how power from cab A reaches a train in block 1 and how cab B can operate in block 3 at the same time. The power passes through a toggle to reach the track. It cannot feed back into the other cab as long as the corresponding block toggle on the other cab remains turned off. Return power mixes in the common return feeder, but causes no interference as each power pack draws out just the amount of current it needs.

16 - 13 Track feeders should be brought to one (or several) terminal strips located near the cab panels. The strip is fastened to the table where it can be reached easily for tests. This is better than putting the strip inside a cab panel. The cabs should be connected to the strips in same way that allows for easy removal for repairs. One method, lower left, uses 1″-long 6-32 brass machine screws, nuts, washers, and "solderless" terminal lugs for the wire ends. The other method uses low-cost solder-on type terminal strips in sets. There's one strip for the track feeders and parallel strips for each cab. Bare copper wire is soldered across to interconnect the strips. This is easily cut to remove any cab.

circuit between the power packs of two cabs would be to turn on the same block toggle in both cabs at the same time. This would pop one of the circuit breakers, so no real harm would be done.

Indicator lamps

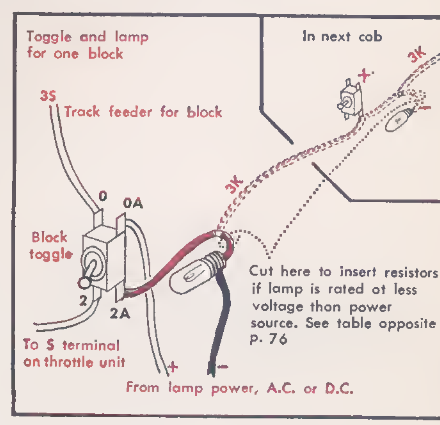
One of the best features to add to each cab control panel is a set of indicator lamps. These show when any cab has a block toggle turned on by lighting up on all cabs. The lamps are located on the track diagram beside or within the appropriate block and near the toggle for that block. As you run the train you glance at the lamps. If one is lit, you will not turn that block's toggle on until the lamp goes out. In this way you can avoid those feedbacks we mentioned awhile ago. You need one lamp and one socket for each block in each cab. Also the block toggles should each have an extra pole. One power source will handle power for all the lamps. More about power for lamps in the next chapter. Fig. 16-14 shows the wiring scheme for one block and two cabs. The proper name for these lamps is block power indicator lamps, to distinguish them from block occupation lamps which are sometimes used to show when an engine or car is in a block whether or not the power is on.

Turnout toggles and lamps

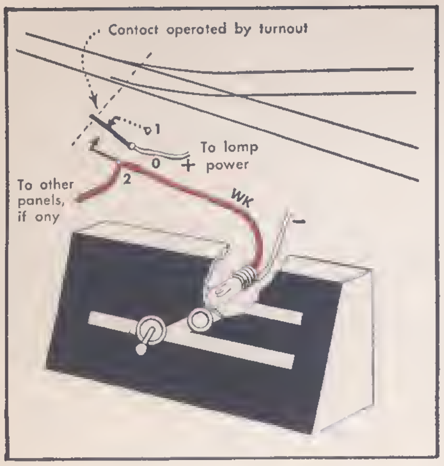
You can also add lamps and toggles to the control panels to show the positions of turnouts. There are three ways to do this that work out fairly well. One is to put the switch-machine toggles right on the main panel but not on any other panel. The turnout control for all parts of the railroad is then under the jurisdiction of one master towerman. Lamps that show which way this man has thrown the turnouts may be repeated on each cab and a good scheme to use here is to use a single yellow bulb for each turnout. When the turnout is thrown for the sidetrack or branch line the bulb warns with its yellow glow. The lamp goes out to show the turnout is aligned for the main line.

The second method is a little better when you're operating by cab control. This is to repeat the toggles which control important turnouts on every cab, thus each engineer can handle turnouts as his train approaches them.

When there is plenty of manpower,



16 · 14 This indicator lamp will shine to show when a block is in use by any operator at any cab panel. The block toggles must have an extra pole to handle the indicator circuit (since lamps operated from the running power wouldn't protect stopped trains). Thus sp. st. toggles would be replaced by dp. st. and dp. st. by 3p. st. toggles or wafer switches. The wire 3K must connect to the block-3 lamp in every cab panel. A similar indiKator wire is provided between the cabs for every other block. The plus and minus for all the lamps for one block must go to the same power source, but if you want to split the load you can power one block's lamps from one pack and another block's lamps from another.



16 - 15 You can use the same scheme as in Fig. 16-14 to operate a lamp to show whether the toggle that operates the switch machine is normal or reversed. However that's no guarantee that the turnout is actually in the desired position. This circuit is better but also more work to install. The idea is to control the lamp from a contact on the turnout's throw rod. Using a single yellow lamp to show when the turnout is in the sidetrack position is simple but some model railroaders prefer to use two lamps, one for each branch. The added lamp would be connected to contact 1 above.

you can put individual towers near each important junction so that the turnouts in that general area are controlled locally by the local "towerman" as is done on a real railroad.

Some folks install an additional master tower something like your main control panel but with toggles and lamps for the turnouts only, no block toggles.

Contacts to control the turnout indicator lamps can be added either to the toggles that operate the switch machines (in the same way that we added extra contacts to block toggles) or else these contacts can be operated by the throw rod of the switch itself. The throw-rod method has the advantage that it shows the actual position of the switch if the switch machine is not working properly. See Fig. 16-15.

Dual-throttle cabs

The dual-throttle-type cab is so versatile, simple to wire, and inexpensive considering what it can do that I feel it is the best design to use for the main control panel on almost every model railroad. This goes for big railroads as well as little ones. Fig. 16-16 shows a dual-throttle panel. Notice that there are two throttles but only one set of block selector toggles. These toggles are of a type we haven't used previously. They move from the left to the right to connect a block to either the left-hand or right-hand throttle. The toggles also have an off position in the center so any block can be made dead. This type of panel is easy for one, two or three people to operate at the same time. Let's talk about operation with two people first.

Assume you have a guest at the panel. The guest isn't familiar with your railroad, so you want to make it easy for him. O. K. You use the left-hand throttle and everywhere your train goes, you throw the toggles over to the left so you get power to the blocks where your train needs it. How about the toggles for the other fellow? Well, if you just throw your toggles clear over to the right each time your train clears a block, all of the blocks you don't need will be connected to the other fellow's throttle, so no matter where he runs his train he has it under control. Sometimes I've called this "father-and-son" control because it's a good one for Dad and Junior.

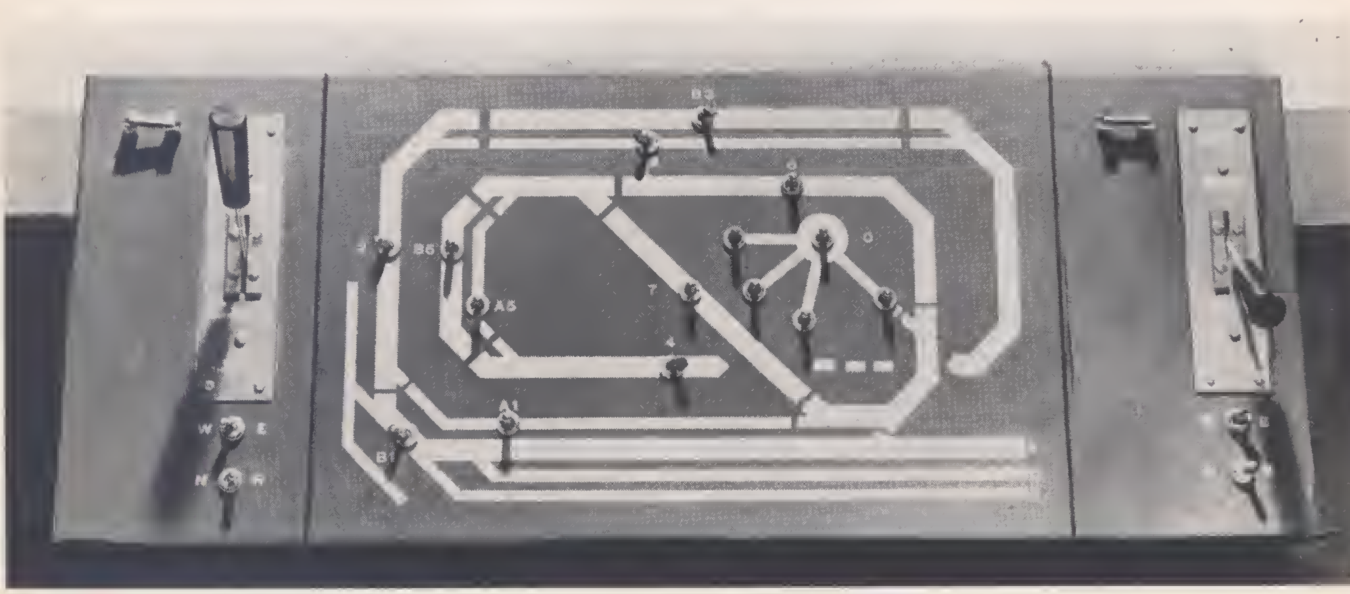
Of course, whether the other fellow is your son or a guest, sooner or later, he's going to learn how to handle the toggles for himself. Then instead of throwing the toggles all the way over, you throw them only as far as their off positions and the other fellow will operate his train in the same way you do, throwing the toggles back to the center-off position when he's through with them.

When you want to use this cab for three people at the same time, one fellow can handle the toggles while the other two each man a throttle.

For solo railroading, you can handle both trains by cab control methods or you can throw some of the toggles to the left and others to the right and operate by section control.

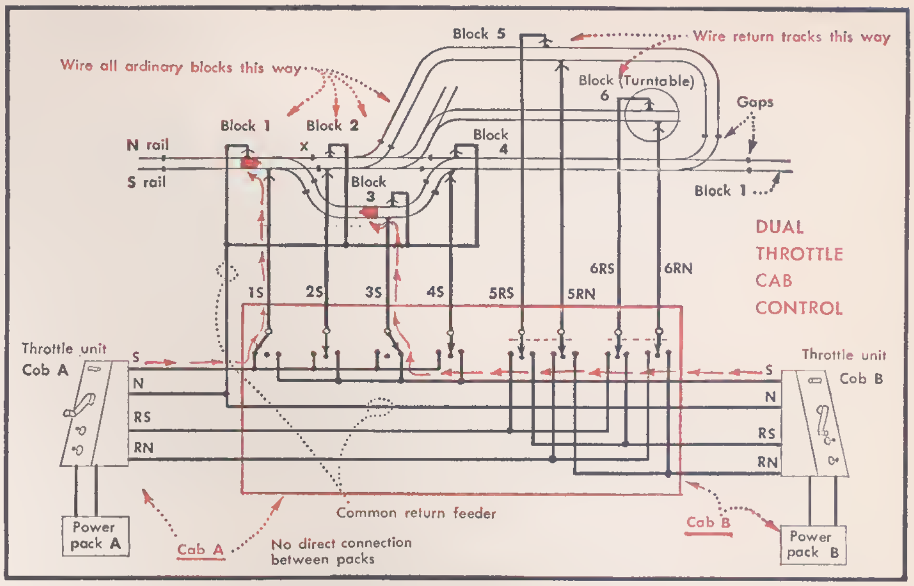
Another way you can operate with this dual-throttle cab is rather unique but sometimes useful. You might call it "speed range" control. You adjust one throttle for a medium speed and the other throttle for a slow speed. Then by operating the toggles from the center, first to the left and then to the right, you can control trains in the various blocks at either of the two speeds or stop them and thus keep quite a few trains going merely by changing their speeds and without having to adjust throttles.

Still another method is to set one throttle unit for eastbound and the other for westbound operation. Then you can reverse any trains in any blocks at will by shifting the power from one throttle to the other.



16 - 16 The dual-throttle type of panel is really two cabs but they share the same selector unit panel. This is the best panel for most pikes because it offers the most control facility for the least expense and because it can handle all types of train operation easily.

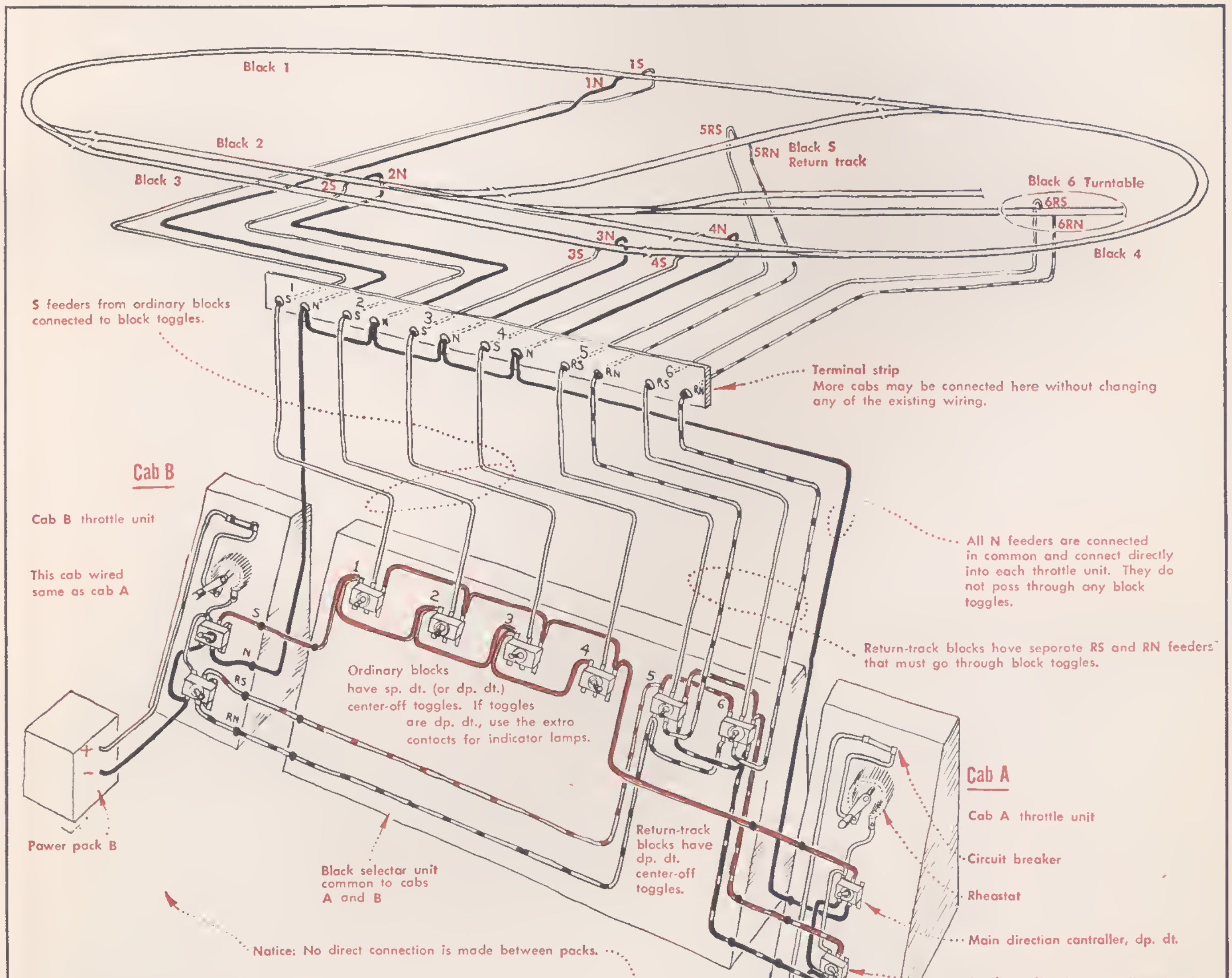
16-17 Toggles do double duty in the dual-throttle cab. This makes the panel simpler to wire than the two plain cabs it replaces.



This versatility of the dual-throttle panel is one of its great assets. The other big assets are its simplicity and cost. Since only one set of toggles is used, the panel doesn't cost as much as the two cabs of the plain type that it replaces and less wiring is required. Since it uses only two rheostats it costs less than the average section control panel which has three or more.

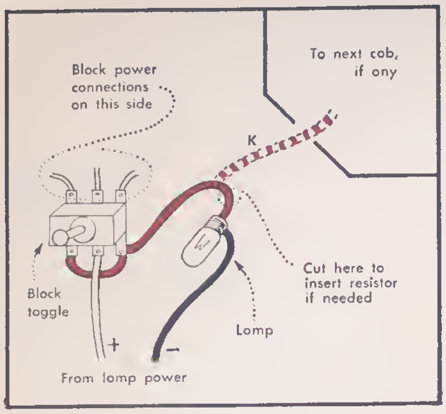
Figs. 16-17 and 16-18 are included here so you can compare the wiring

16-18 Dp. dt. center-off type toggles are shown for all blocks in this panel, below, but sp. dt. center-offs could be used for ordinary blocks if you can get them. If you want to add indicator lamps, see page 67.



Cab control

with dual throttle panel, using multiple power supply



16 - 19 Indicator lamps for dual-throttle cabs are wired the same as in Fig. 16-14 except that the indicator wire (colored) must reach two places on the toggle. Thus the light will burn when the switch is thrown to either side.

for the dual-throttle type control panel with the other panels described in this chapter.

I should point out one interesting feature of the dual-throttle cab that isn't shared by some of the other types. Since it is impossible to throw the same block toggle both to the left and to the right at the same time, you cannot have a feedback between the two throttles. You can have a feedback between either throttle and other cabs, so indicator lamps are still worth installing. Fig. 16-19 shows the circuit for these.

When you make up your parts list for a dual-throttle cab, you will need at the simplest one sp. dt. center-off toggle for each ordinary block and a dp. dt. center-off toggle for each turning track. However, since it is advisable to add an extra pole to these for indicator lamps, you may prefer to use four-pole three-position single-gang wafer switches for all blocks. Then you will have enough poles to handle ordinary and turning track blocks as well as the lamp circuits and in addition you will have an extra pole or two for other purposes that you might think up in the future. These wafer-type switches will also often cost less than ordinary toggles.

On page 67 you'll find the drawing of a complete cab control installation using a dual-throttle control panel. Four-pole wafer switches are used to provide for indicator lamps for both blocks and turnouts.

If you already have section control

If your railroad is already wired for section control, it does not prevent you from having the advantages of cab control. You can either add cab control panels to the railroad as it is without changing the section control part of the wiring or else you can add a few toggles to the original control panel so that each throttle can handle blocks in what was once the exclusive territory of other throttles.

For instance, if one of your throttles formerly handled four blocks on the inner oval of a double-track oval, you can add four more block toggles so the same throttle can handle the four blocks on the outer oval as well. Do the same thing to the throttle that formerly handled only the outer oval and you have converted your panel into a two-cab system for a cost of less than five dollars.

How to build the control panel

If things still seem strange to you, you can take your time as you build your control system. Read about power packs in chapter 17 so you can buy a pack and throttle. You can connect all blocks together temporarily at the terminal strip so you can have trains moving even if you cannot operate them independently.

I made the control panels in the photos the same as in Fig. 5-6 except that their width was increased. A Prestwood panel front was shellacked and then painted reefer yellow. Over this I laid 1/4" strips of masking tape to represent the tracks, using 1/2" strips to emphasize the main routes. This is easier to "read" than when all track is made with the same width of tape.

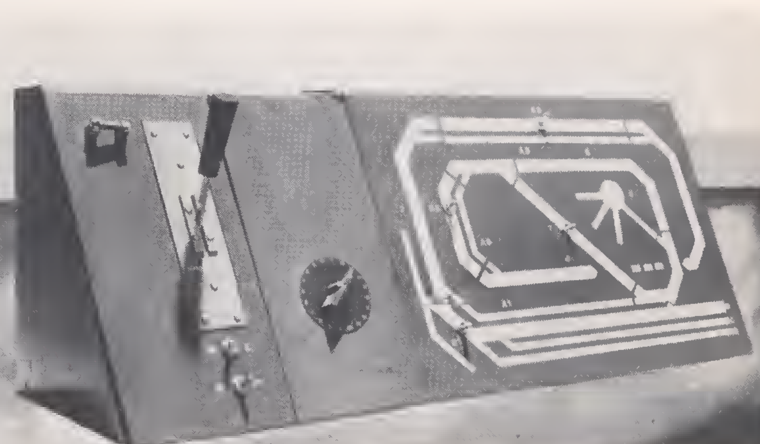
I laid all horizontal tapes first and then verticals, starting with the outermost tracks 1 3/4" from the parallel edges. I stretched the tapes all the way across the board, Fig. 16-20. Then I added short diagonals to represent curves. Next I laid all the toggles in place to see if there would be enough room for them. This showed me that some of the "track" should be adjusted one way or the other. The idea is to get a plan purposely distorted to make the most room where the most toggles will be needed. At this stage you may discover that a larger panel is necessary, so it's better to do this step before building the box behind the panel.

Finally I trimmed the overlapping ends of the tape, cut 1/16" gaps to show block boundaries, pressed all edges tight to the board, and sprayed the panel black. You can daub stiff black paint with a sponge if you lack spraying facilities — or an auto body shop can spray it for you. Some folks use colored tapes on a black panel and avoid the paint method entirely.

Next I added decals with setting fluid. Finally I gave the panel a coat of dull varnish of the kind used by furniture makers to get a "rubbed effect."

While large wire is recommended

16 - 20 I sprayed this panel front with reefer yellow and now I'm adding masking tape to represent the tracks. I won't cut the tapes to final length until I'm sure there will be room for every toggle in its place. Curved track will be represented with diagonal strips and the main track is made wider than all yard and passing tracks to emphasize the route.



16 - 21 To the right of the controller unit on this route type cab is the black selector unit. You turn its rotary switch a notch at a time as your train moves along its line. You can run the train anywhere you wish but the route you plan to take must be set up on the route board at the right. This directs the rotary selector along the proper track between junctions.

for long track feeders, smaller wire is adequate and easier to use inside the control panels. Size 18 stranded is most used but even size 20 is safe for one-train circuits. Rubber or plastic insulated wire is available at most hobby shops.

Soldered connections are by far the easiest to make even though you may not like soldering ordinarily. Just be sure the connections are sound mechanically before applying the solder. The purpose of the solder is to lock the connection in place and to prevent oxidation of the wire surfaces where they touch. Use only rosin-core solder; other fluxes eventually eat the metal away.

As your railroad grows

The control system you now have, or will soon build, may be all the control equipment you'll ever need. But if you want to run *more* than two trains in railroadlike fashion, a time will come when you'll add another control panel.

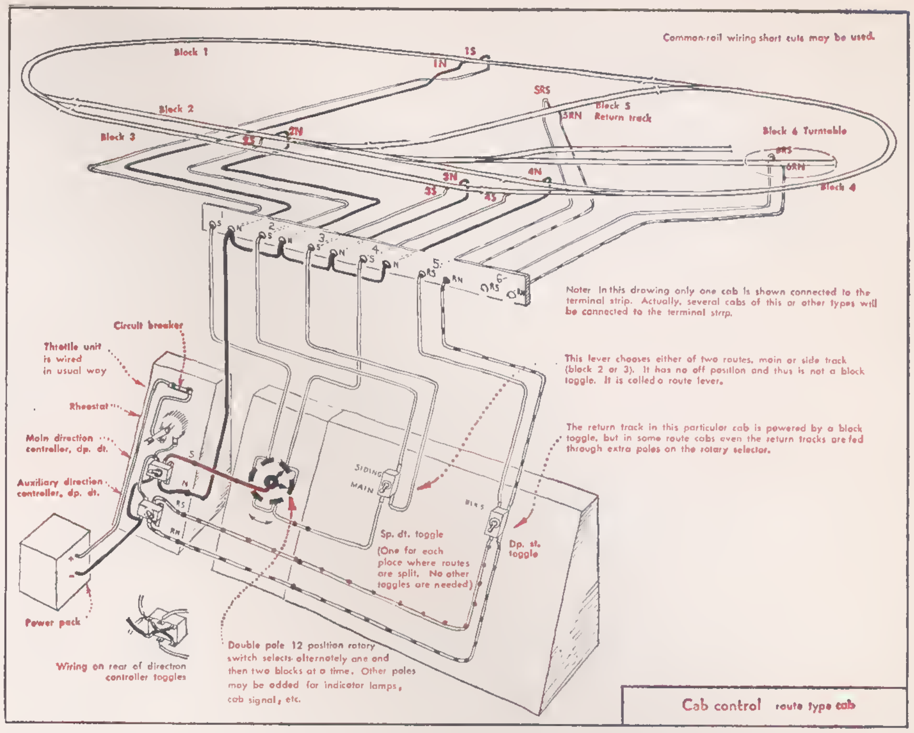
But don't blindly build another panel just like your first until you've thought things over a bit. Maybe you won't need toggles for *all* the blocks on your next panel. Maybe a somewhat different arrangement of the controls will add more fun to your train operation. Besides, if you don't need as much equipment on your extra panel, it will cost less and be just that much less to maintain. What to omit depends on how you operate.

Yard cabs and road cabs

If you find you need more switching capacity, consider building a panel that has toggles for all the blocks and switch machines in a particular yard. It should also have toggles for blocks that might be used by the yard switcher on the main line nearby. All of these block toggles will of course be duplicates of toggles on the original main control board.

Use double-throw center-off switches for the blocks. Wire them the same as for the dual-throttle cab, only this time install only one throttle, the one at the left. In place of the right-hand throttle, bring the *S* connection to a terminal marked *YB* for "yard bus." A bus is a terminal where three or more circuits can connect. In this case the road cabs we're going to talk about next can connect here.

The idea is to allow any road engineer to pick up his train right in the yard. In the old days the yardman usually had to run the train out onto the first block of the main line for him. With this arrangement, any part of the yard connected to the yard bus is available to the road engineer. At the same time the yard switcher



16-22 In a route cab, power from the throttle unit is directed to the proper block by a rotary switch, or sometimes a pushbutton selector. Since the switch can handle only one route, a route board is added to direct power to the main or branch track at each siding.

Route Cab Wiring

The diagram above shows how you get away with so few parts when building a route cab. But this drawing is oversimplified; in actual practice you'd include more features than are shown here.

For instance, the rotary selector usually has five or six moving poles instead of only two. Here is how they are used:

Pole No. 1. Is used to direct power to the block your train is in, the "rear" block.

Pole No. 2. Directs power to the block ahead of your train so it will not jerk as it crosses into the new block, the "mid" block.

Pole No. 3. Connects a relay to the **S** rail of the block next ahead, the "advance" block. This relay operates a cab signal to show if a train is in that block. It also protects you if some engineer using a toggle panel has forgotten to turn his power off.

Pole No. 4. Is used to determine polarity on railroads where trains frequently run through return loops, wyes, and other turning tracks.

Pole No. 5. Is an index pole. It can light lamps on a track diagram to show you where you are running. It can also tie into the indicator lamps of any toggle-type cabs that are being used at the same time.

Pole No. 6. Is used to operate the turnout indicator and control circuit mentioned on page 66.

Extra poles are also added to the route levers to handle some of these same circuits.

In the diagram, Fig. 16-22, you'll note that you get power to first one block and then two as you notch the block selector around. More often power is sent to two blocks at every position. This cuts the number of positions needed on the switch in half. But then a toggle or relay must be added to cut power from the rear block whenever you pull up to a stop. That's so another train can pull into your rear block without a feedback to your throttle.

You would expect to turn the knob one way to go east and the other to go west. But usually the circuits work out better if you always turn the knob the same way for running in either direction. Then you add a separate switch (or more positions on the same switch) to change the connections for operation in either direction.

On a loop-to-loop or a dogbone-type track plan, for instance, the length from loop to loop might be six blocks. But the rotary switch can be nicely arranged with not six but twelve positions. Positions one to six connect to blocks one to six going east. Positions seven to twelve connect to blocks six back to one, but now going west. Get it?

The route board would then have not one but two route levers for each place where you can choose routes. Suppose there is a passing track at block 3. One lever will determine whether you take the main or the side track on your eastward trip, position 3 on the selector. The other route lever takes its effect when you return westward, again to block 3 but now at postion 10 on the rotary block selector.

A particular rotary switch may have too many positions, in which case several are tied together and at this point the engineer moves the knob several notches.

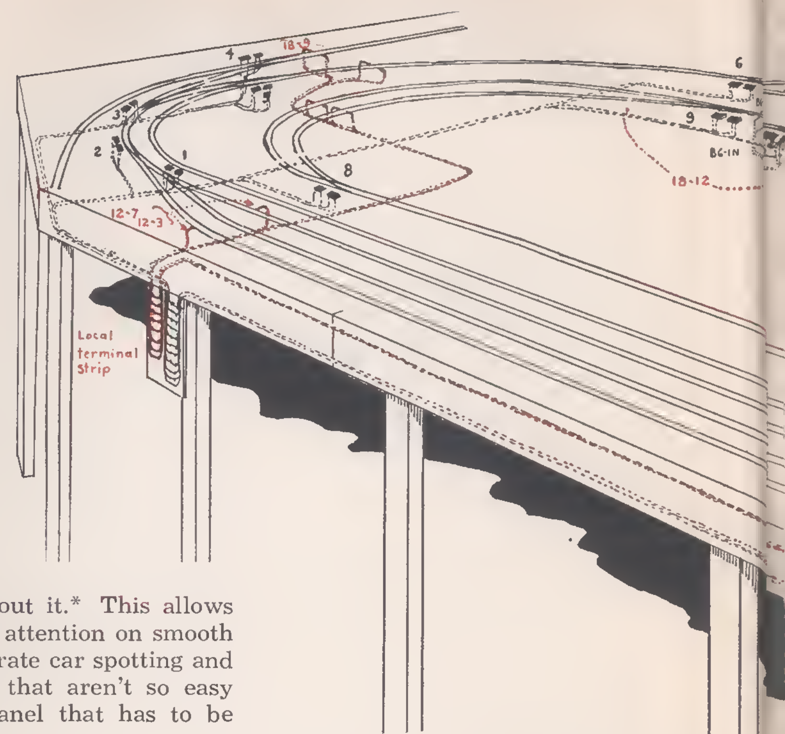
On the other hand, if you cannot get a selector with enough positions, you can use two or more. One can be used for each direction (a good idea anyway) or you can have the last position on one selector connect into the moving wipers of the next rotary.

In PCC cabs, chains of interconnected relays can augment or replace the rotary switch. One relay operates to connect you to one block and another relay to the next. This is ideal but expensive.

You'll find more information about power packs and how to buy them in chapter 17.

may use other parts of the yard, all depending on whether the yardmaster moves his toggles to the left or right.

If, and this is more often likely, you find you need capacity to operate more trains on the main or branch lines, build one or more "road cabs." The usual way to do this is to build a panel along the lines of the plain cab (as in block control), but providing toggles for only those blocks that road engineers will run their trains through. If you built the yard cab just mentioned, your new road cab will need only one toggle for the entire yard. When you flip this on, it connects your throttle to the yard bus. And it's up to the yardman to connect this bus to the particular yard track where your train is waiting.



This drawing is a sort of index to much of the material in this book. Numbers in color refer to pages and diagrams where you can read about the details of various features. If you choose to operate your own railroad with a dual-throttle type panel, with multiple power supply, and with indicator lamps for both blocks and turnouts, your wiring will look something like this. In this example, Mallory number 3242J rotary type single-gang switches are used to control twin-coil switch machines equipped with cutoff contacts. This is quite an improvement over the two-pushbutton method. Likewise, Mallory 3243J switches are used for block control. Any switches of at least dp. dt. and 3p. 3t. may be substituted as long as you keep track of which contacts on the switches are connected to the moving poles. In these particular switches the four moving poles are in the center.

Route cab control

Another type of road cab is receiving considerable acclaim wherever it is installed. This is the "route cab," an example of which is shown in Fig. 16-21. Route cabs are the simplest and least expensive of all cabs, yet among the best from the operating standpoint. I'm sorry that space allows me only to tease you about route cabs in this book. The best I can do is introduce the idea to you and here I must state one warning. Route cabs are not easy to design. What you gain in smooth operation, realism, low cost, and electrical simplicity, is partly paid for by many hours of paper work spent figuring out the circuits beforehand.

The idea of the route cab is to make block selection as simple as possible. With a route cab, Fig. 16-21, you run your train like this: First you decide where you want your train to go. You set this route up by moving the toggles on the "route board" at the right of the photo. You'll notice there are not as many toggles on this panel as on an ordinary panel. These switches are called "route levers" and you need them only at places where the train has a choice of two or more ways to go. The route set up in the photo shows the train taking the main line at all sidings.

After you've recorded the route you want to take, you start your train. And while your train moves from block to block, you turn the "block selector" knob (the center unit of the cab) a notch at a time. This sends power to first one block and then the next as your train moves along. The power will go to whatever sequence of blocks you have set up on the route board. Notice that you don't have to touch the route levers while running your train unless you want to change the route. Since the knob turning is so simple, you'll find you do it without even thinking about it.* This allows you to keep your attention on smooth starts, stops, accurate car spotting and other maneuvers that aren't so easy with a control panel that has to be watched.

Since toggles are needed only where there is a choice of routes, far fewer toggles are needed when you build a route cab. Also the rotary switch will cost much less than the toggles it replaces so that's where you save money.

With a route cab it is easy to add a one-relay cab signal that will show what's happening on the track in every block your locomotive approaches. This feature alone is worth a lot of consideration. It's also easy (and without any relays) to add another signal that shows when a turnout isn't lined up the way you planned to go as you approach a junction. If there's no towerman present to correct the turnout, you can push a single button in your cab and it will operate the switch machine whichever way it should to give you the route you want. These added signals and remote turnout control features cost less than the indicator lamps you'd install for the same purposes on toggle-type control cabs.

Progressive cabs

If you make a cab signal with four relays in it (a "pilot unit") you can then add a coil to operate the rotary block selector automatically. The toggles on the route board also can be replaced with relays and you then have completely automatic block selection, leaving you the throttle, reverse lever, and perhaps a brake handle as the only controls in your cab. When you have automatic block selection by this or any other scheme you have "progressive cab control" or for short, PCC.

A PCC cab can also run a train for you. If you haven't any guests, you can switch trains in the yards while a PCC cab or two runs more trains down and back on the main line. In this way one man can keep a whole railroad operating realistically.

You may guess that I think quite highly of the possibilities of route cab control and PCC. I do. But perhaps it is just as well that there is no space for details about them in this book, as the techniques are still being improved at a rapid rate. If you are interested in doing a little pioneering of your own with route cabs or PCC, I've included some suggestions about the most asked questions in the small print under the wiring diagram, Fig. 16-22.

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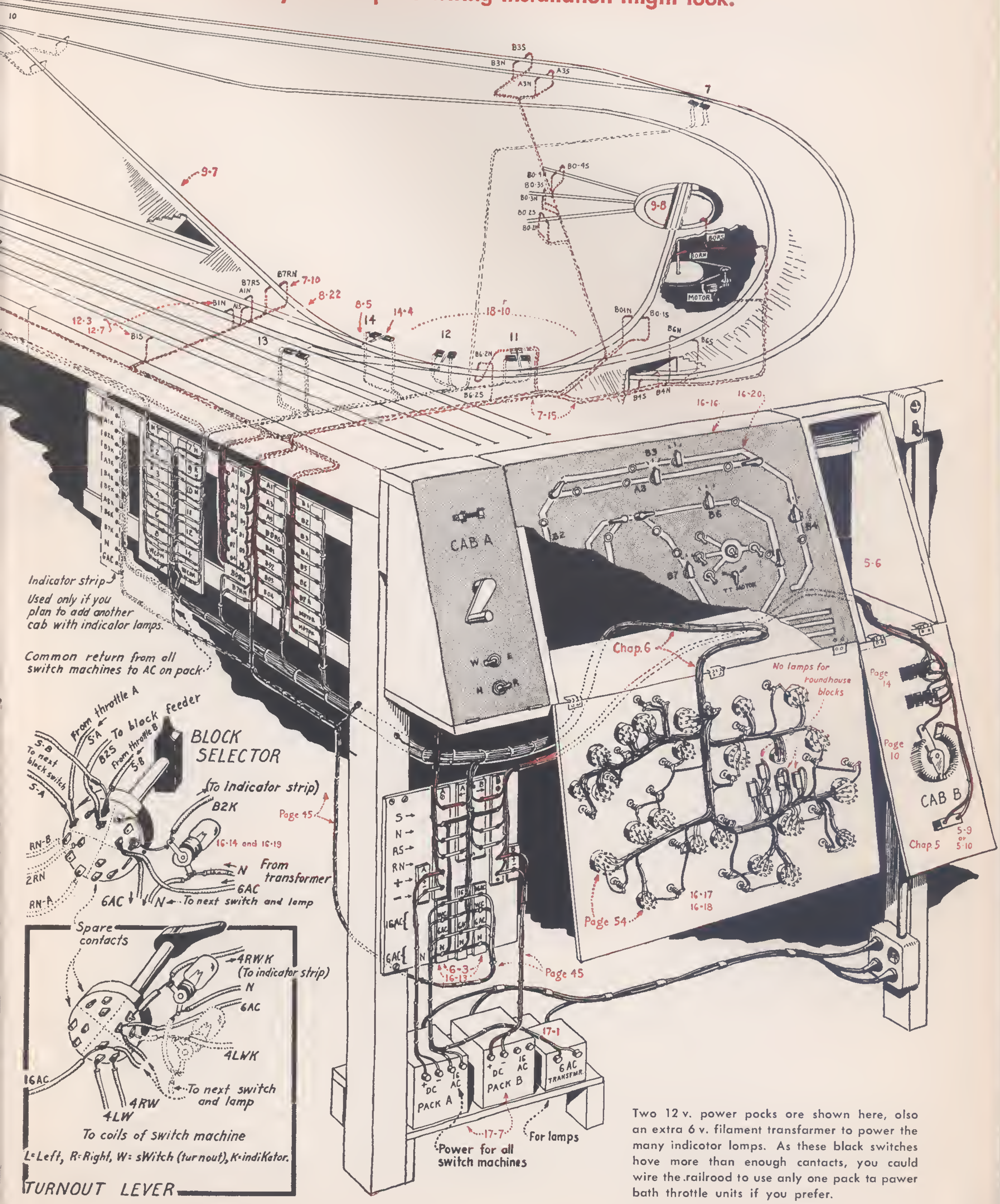
*Sometimes a row of push buttons like those on an automobile radio are used in place of the rotary selector.

Control Panorama

How your complete wiring installation might look.



Two 12 v. power packs are shown here, also an extra 6 v. filament transformer to power the many indicator lamps. As these block switches have more than enough contacts, you could wire the railroad to use only one pack to power both throttle units if you prefer.

How to Select Your Power Pack

WHEN you go to a hobby shop to buy a power pack you may be faced with an amazing array — little packs, big packs, packs with throttles and packs without them. There's a good sales argument for each kind too, so before you buy here are some questions to ask yourself. I'm sure the answers will help you in making power pack decisions.

1. Must I conserve all I can in spending for a power pack or can I afford a little more to get better operation?

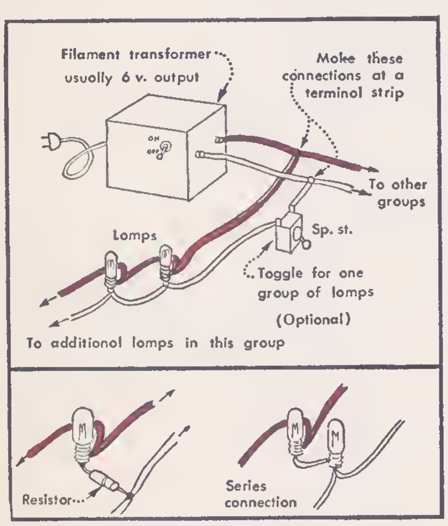
2. Would I like to buy my power pack a little at a time rather than plunk down a big sum at the very beginning?

Financing is only one consideration. Here are other points equally important about how you will build and operate your railroad.

3. Will I always have a small railroad?

4. Or will it start small but grow until I can run three or four trains?

5. Do I want the controls arranged so that friends or perhaps others in the family can also run trains?



17-1 Whether you use a separate transformer or your power pack to power lamps, the wiring is the same. If the transformer voltage is too high for the lamp, a resistor, lower left, should be added. See table facing page 76 for resistor data. Two lamps can also be used in series, lower right, in which case the lamps should have half the voltage rating of the transformer.

6. Will I let the trains run more or less by themselves while I do other things around the pike?

7. Or do I prefer to stress smooth starting and stopping — emphasis on the engineer?

We've plenty of work to do so let's get started. Let's figure roughly how much power your railroad will eventually use by making a guess and a simple addition. First estimate how many locomotives you will eventually acquire. If you're in TT, HO or S gauge, make a list and allow 1 a. apiece for one-motor engines and 2 a. for two motors etc. O gaugers must allow 4 a. for the largest motors and 2 a. for the rest. If you want to be more accurate you can use the motor ratings from the table on page 13.

This kind of figuring has a limit because model railroaders often acquire more engines than they can run at one time. If your track will handle only three trains at a time, strike off all but the three biggest engines from your list and then total it.

Here's an example:

Two-motored diesel	2 a.	
4-6-2	1 a.	
2-8-2	1 a.	
Diesel switcher	1 a.	Strike out
0-4-0	1 a.	Strike out
Total: 6 less 2 is	4 a.	Maximum

This will be conservative because many engines do not draw as much as 1 a. apiece. Add to your total the power needed for any other equipment such as lamps and switch machines that you'll be running from the same pack. Lamps will be the biggest item. They look innocent enough but they use a lot of electricity. If you don't know the actual current rating for your bulbs, figure them at five lamps to the ampere or use the table opposite page 76.

Lamps in the trains will have to run from your power pack but you can often save money and have a better light system if you power street, signal, control panel, and scenery lamps from a separate transformer as in Figure 17-1. A toy transformer can be used or you can get a filament transformer such as Stancor No. P-8130. This is a radio part that retails for around $5. If you cannot get it from your hobby store a radio repairman can order it for you. It has two 6 v. 2 a. circuits. From it, you can light 20 or a few more 6 v. bulbs either No. 40 or No. 47 size, or you can use the two circuits together to operate ten 12 v. bulbs. It will also handle most makes of two-coil switch machines.

Although most switch machines draw a lot of current you don't have to allow any extra power for them because they operate for such a short time that they do not overheat the pack. The only exception to this is the one-coil machine. Allow 1/3 a. for each Pioneer machine or 1/6 a. for each war surplus rotary. Of course not all these machines will be operated at the same time so figure the maximum you will have in the "on" position regardless of the total number.

Your grand total may be something like 2 a., 6 a., or as much or more than 15 a. but this doesn't necessarily mean that you should go out and buy a pack that size. You may want to split the power among several packs. Here are the advantages of using one big pack, followed by a list of the advantages of having several small packs instead. Think of your answers to the questions in the first part of this chapter as you read.

Single power supply

The one-big-pack idea is called "single power supply," and it is the most obvious and oldest way to power trains. Its biggest advantage is one of cost. You get more ampere-handling capacity for the dollar in a big pack. You aren't paying for any duplication of parts.

Then there is the simplicity of having only one pack to turn on, maintain and build a shelf for.

When you use a single power supply for two or more trains you may want to buy an otherwise oversized pack to get good "regulation." Perhaps you've noticed how one train slows down when you start another. This is due to poor regulation in the pack, inadequate wiring, or both. The parts in a power pack must be large and carefully designed to get good regulation. The packs that look alike on the outside may be unlike in cost because of what is inside.

The other way to wire your power

is called "multiple power supply" and it completely eliminates trouble from poor regulation, even though you might use a poor quality pack to save money.

Multiple power supply

Here you start with one pack but instead of getting a pack big enough to handle all future trains and to insure good regulation, you do the opposite. You buy a small, perhaps cheap pack that will handle one train or perhaps a double-header. When your railroad is ready for a second train you get a second small pack. If you plan a four-train railroad, you eventually get four packs. In the long run you'll pay more for this kind of power supply, so what are the advantages? Here's what users of multiple power supply point out:

1. Low first cost.
That's because you start with a small pack. The quality of the pack can be lower too, a possible further saving in cost.

2. Installment plan buying.
You pay for your power plant a little at a time as you add more packs to run more trains.

3. Nothing becomes obsolete.
Since your power plant grows with your railroad it's never too big or too small. The units will be equally suitable for any other size of railroad — if you move to a new home or change the size of your pike.

4. Best possible engine performance.
Since each train will operate from a different power pack, there will be no slowing down, stalling, or shooting ahead of one train when others are started and stopped. Also there is no need to have good regulation in the pack. This is why you can use a lower quality pack, yet still have perfect locomotive performance.

5. Packs can be suited to their jobs.
This is more important on a big railroad with many trains. You can have one or two of your power packs larger than the others to handle four-motored diesels, double-headed freights and the like.

6. Wiring can be simpler.
This is a most important point especially for medium and large railroads. When you build enough controls so you can handle three or more trains and do some yard switching at the same time, anything that can keep the wiring simple is worth a little more money.

The cab control drawings in chapter 16 show multiple power supply wiring. Compare Fig. 16-13 with Fig. 17-2 which shows the same cabs rewired for use with single power supply, one pack for all cabs. Notice how the *N* feeders as well as the *S* feeders now pass through toggle switches. The switches themselves must have one more pole than before, either double-pole or if you also want lamps, at least three-pole.

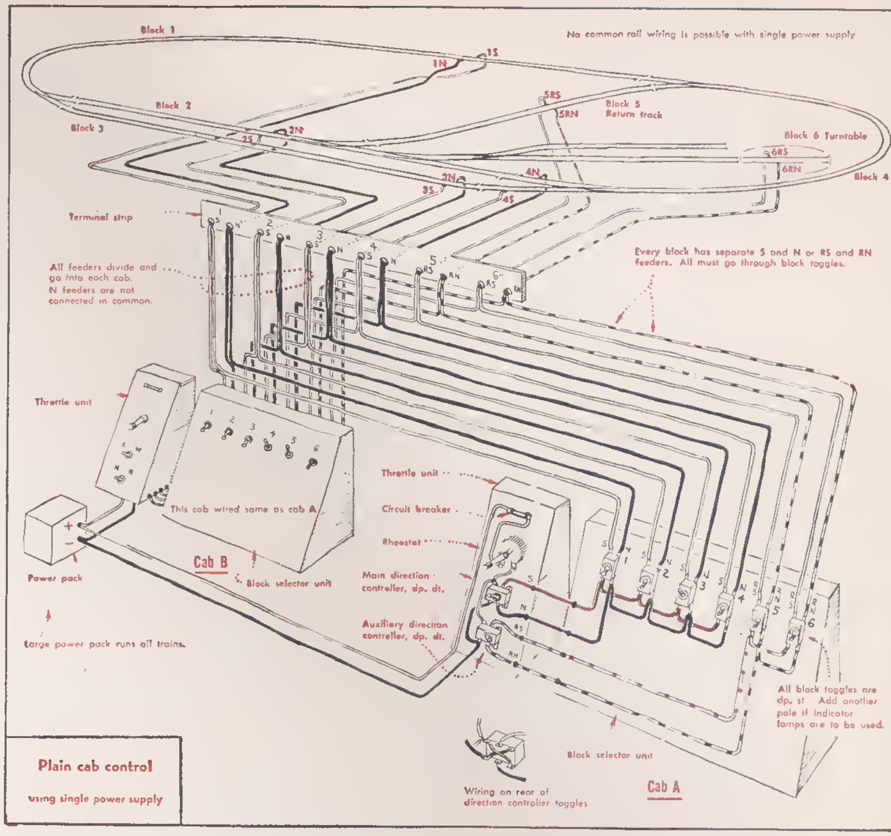
Common rail wiring short cuts

With both multiple power supply, and twin supply, (which we're going to see in a moment), your *N* feeders do not pass through the toggles. Instead they are connected together at the terminal strip. We called this "common rail" wiring.

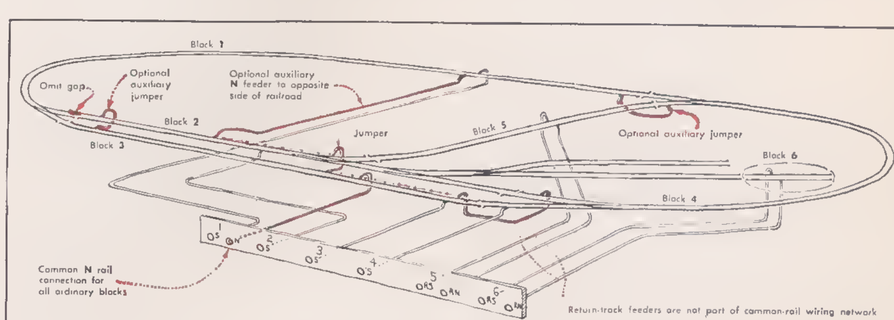
With this scheme, all the *N* feeders must be tied together. Usually, but not necessarily, this is done at the terminal strip. Sometimes it's easier to join them nearer to the track.

Fig. 17-3 shows the same track plan we used so often in the last chapter, but now all the *N* feeder wiring is done with various short cuts.

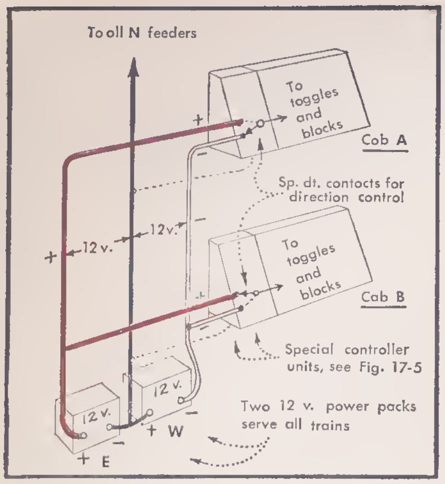
This new arrangement can be used in place of the old one on all the diagrams except the one for section control. It will work equally well and be simpler to build. What we did here was eliminate any gaps between the *N* rail of one block and the *N* rail of another except where those gaps are still required to prevent short circuits through turnouts. Then, because some of the *N* rails are now connected together, we don't need as many track



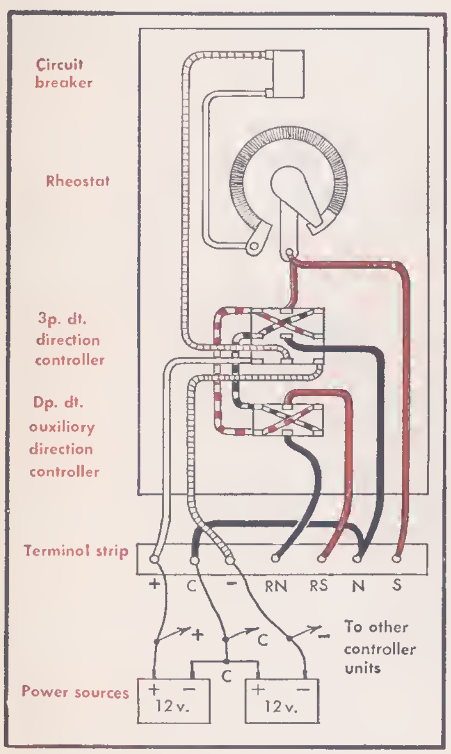
17-2 When one power supply is used for more than one control panel, all **N** feeders as well as **S** feeders must be broken through the block toggles. This requires one more pole on each toggle, and **N** feeders cannot be connected in common. Also there must be gaps between both rails at every end of each block. This same doubled-wiring scheme can be adopted to the twin-throttle type of panel if you want to use the same power pack for both throttles.



17-3 Instead of bringing all four **N** feeders to the terminal strip, you can interconnect the **N** rails like this if you use common-rail power return. The advantage is that less wire is used. The disadvantage is that it is easier to make a mistake. After you have the system working properly, add the optional jumpers one at a time, testing as you do. These will improve the current distribution by providing several paths from each block.



17 - 4 Two 12 v. power packs (or batteries or generators) are connected permanently in series to make the "twin power supply" circuit. This is better than using only one power source for all cabs because the wiring in the cabs can be simpler and because the track can be wired in the "common rail" manner. The controller unit must be wired differently from usual, see Fig. 17-5. The sp. dt. direction controller selects one pack or the other. Because the polarities of the pack are opposite, this makes the train go eastbound or westbound.



17 - 5 The drawing in Fig. 17-4 shows only an sp. st. switch for direction control with twin power supply, but if you have a turning track, a 3p. dt. switch is needed and it should not be of the center-off variety. Otherwise trains running around a return loop will jerk at the moment when you reverse the main direction controller. At right, Fig. 17-6, is the same controller with the handy Mallory number 3242J single gang switch replacing the hard-to-get triple-pole toggle.

feeders. It is permissible to connect from the *N* rail of one block to the *N* rail of another to reduce the total number of feeders that must come to the terminal strip. There are many ways to take short cuts here and how you do it will depend a lot on the actual physical arrangement of your own track plan. Fig. 12-5 shows some of the tricks you can use for *N* feeders when you have a common-rail wiring scheme.

Which system to choose

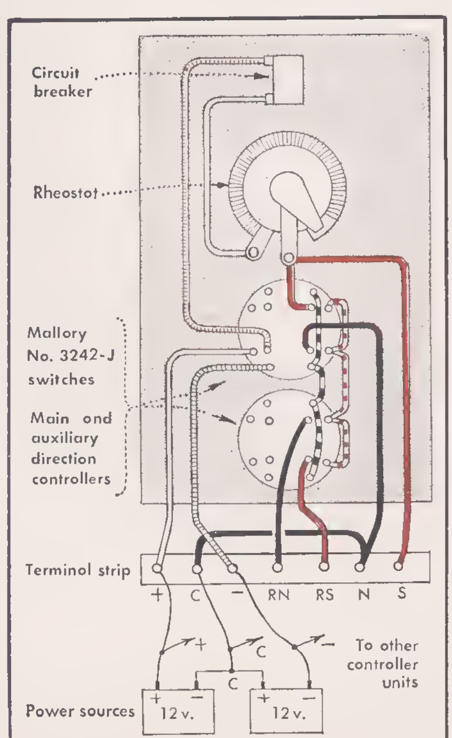
You may not understand all the differences between single and multiple power supply at once, so here is my personal opinion about which is best for whom. Single power supply is for the man who wants to keep the total cost down and also for the man who is not so much interested in the operation side of the hobby as he is just to get a test or display track going where he can run his rolling stock.

Multiple power supply is for the man who will appreciate the simpler wiring. It is also for the man who isn't sure how large his railroad will grow. Multiple power supply also offers better opportunity to run trains in a realistic way with smoother starts and stops. If in doubt, use multiple power supply.

If you already have a large power pack but would like to get the advantages of the simpler wiring, there's another power system called "twin power supply" which you can use.

Twin power supply

Twin power supply is a sort of compromise system with some of the advantages of both single and multiple power supply. It is a way in which a man who has already purchased a big power pack, or who wants to use storage batteries or generators, can get better wiring without having to scrap his pack.



With twin power supply you have the advantage of a fairly low total cost (although the initial investment is high). You have the disadvantage of running more than one train from the same pack and therefore more of a tendency for one train to shoot ahead when another stops. This effect is negligible with storage batteries. Most important of all, you have the same advantages of simple wiring in your control panel as with multiple power supply.

Two power sources are used when you have twin power supply and your direction controller is arranged to draw power from one pack or the other, depending on whether the train is to move east or west. All eastbound trains take their power from the "east pack," all westbound trains from the other pack, Fig. 17-4. Obviously, each pack must be a large one, large enough to handle all the trains that will move in one direction at the same time.

The controller unit for a twin-powered cab must be wired specially as shown in Fig. 17-5, but from this point on to the track, the wiring is exactly the same as for multiple power supply.

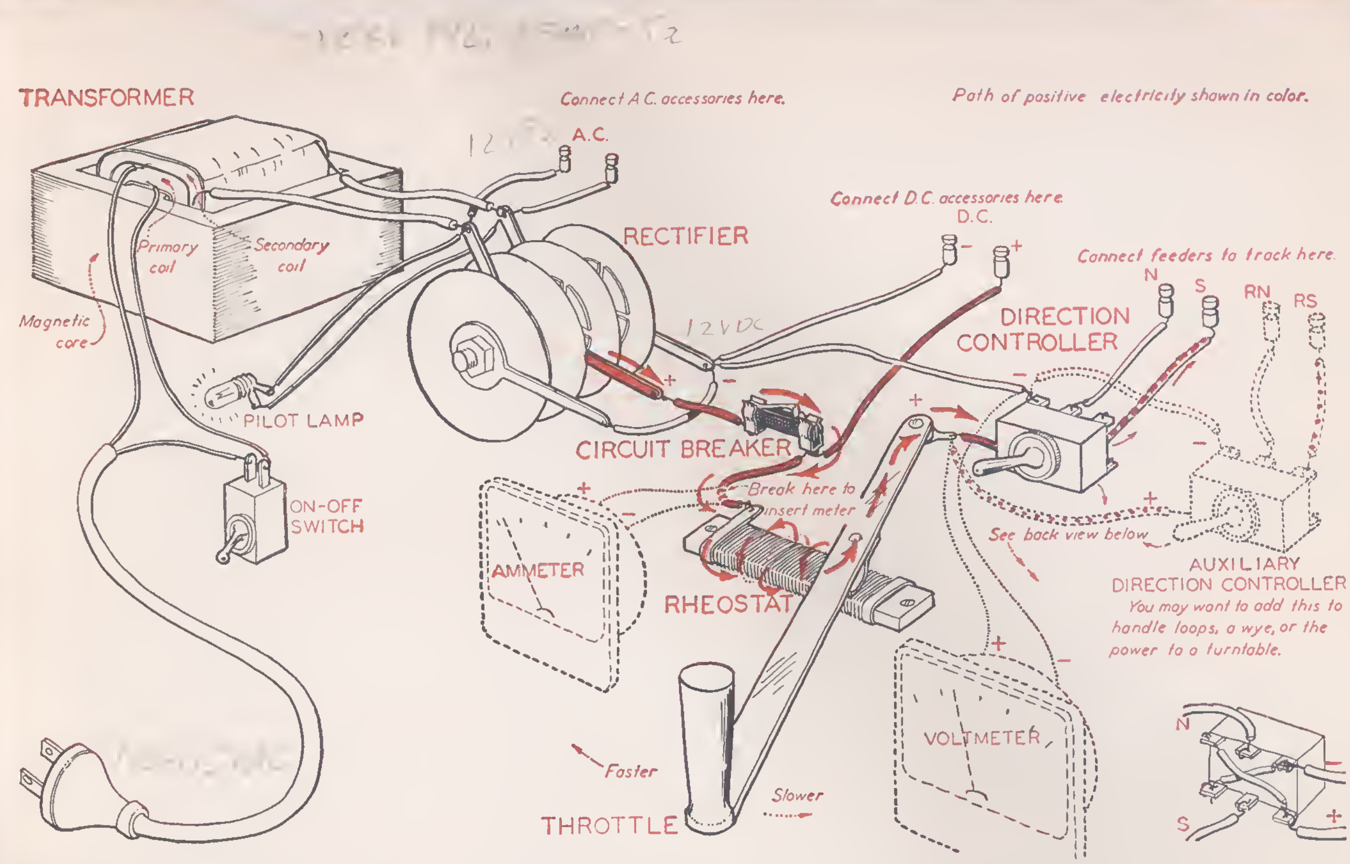
Since both twin power supply and multiple power supply railroads are wired for common-rail power return, you can use both kinds of power supply on the same railroad. If you outgrow the original twin supply, additional cabs can be powered by multiple supply.

No short circuit through common rail

Notice that the plus side of one pack is always connected directly to the minus side of the other with twin power supply and frequently with multiple power supply, Fig. 17-8. This common connection is also tied in with the *N* feeders of all blocks. This plus-to-minus doesn't constitute a short circuit because plus and minus terms are relative and refer only to an individual power source. If you connect a voltmeter across the packs it measures 24 v., but this much never reaches the trains, as only one pack or the other is connected between the *S* and *N* rails of a particular block at any particular time.

Power packs with throttles

Power packs come both with and without throttles. If you're going to operate more than one train with the same pack, a single built-in throttle



17 - 7 The interior of a typical full wave power pack is wired something like this, although some of the accessories, or even the throttle and direction control toggles may be omitted. Circuit breaker is sometimes installed between the transformer and rectifier to protect the latter more effectively.

is no good by itself. You'll either want to add more throttles or start with a pack that has no throttle at all and provide your own throttle unit. On the other hand if you plan to operate only one train from each pack (multiple power supply) a built-in throttle will save you money. Sometimes packs are offered with two or three throttles built in. It is important to ascertain how these packs are wired inside, for if all the throttles are powered from the same full-wave rectifier — or even if there are several full-wave rectifiers but they are powered from the same secondary coil of the transformer — you cannot use these individual throttles for any of the control wiring schemes that have a common-rail power return. Otherwise there would be inherent short circuits. If half-wave rectifiers are wired as in Fig. 17-10, or if each full-wave rectifier has its own secondary coil on the transformer, you can use the multi-throttle pack on a common-rail pike.

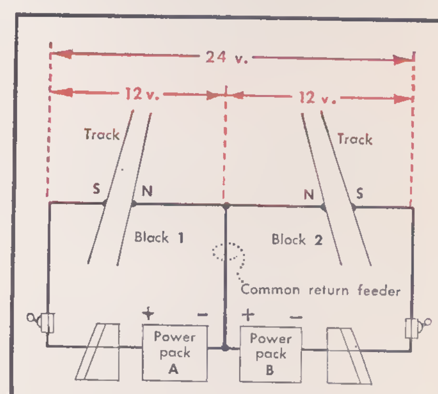
When the manufacturer designs a power pack — or any other electrical equipment for that matter — he is particularly concerned with how he is going to get the heat away from the various parts and into the air. This is why a 10 a. pack must be made of heavier parts than a 5 a. pack. It's going to produce more heat, so needs more surface area on the parts to keep it cool.

What's inside a pack?

The picture diagram in Fig. 17-7 shows the parts you might find in a very complete power pack. Most packs don't have all of these parts. The two parts you'll find in every pack are the transformer, upper left, and the rectifier next to it. These convert A.C. (alternating current) electricity from the high voltage of your house mains into low-voltage A.C. current and then into D.C. (direct current) which is necessary for the permanent magnet motors in your trains. All the rest of the parts are conveniences, except perhaps for the circuit breaker. This is insurance. The circuit breaker is supposed to open the connection before any damage is done to the power pack due to a derailed train or other causes of a short circuit.

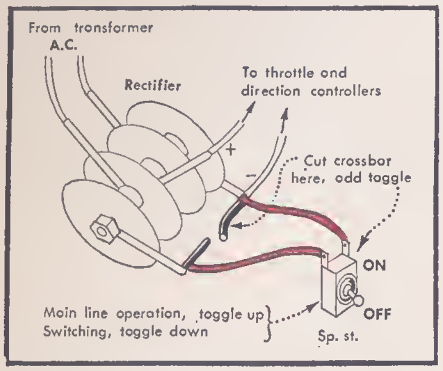
Pulsed power

The pack shown has a full-wave rectifier. This means that the current is switched so that each half of the A.C. pulses forms a D.C. pulse that is furnished to your train. Sometimes a pack is built with what is called a "half-wave" rectifier. In this type the current is rectified into pulses of around 24 v. D.C., but these occur only half the time. Therefore the average voltage to your train at full speed is about 12 v. This type of "pulsed power" operates trains extremely well at very slow speeds. This advantage of pulsed power was discovered by Moyes J. Murphy of Monrovia, Calif., when he used a motor-operated interrupter to chop power from a storage battery. When I heard how well engines performed with Moyes's device I tried using half-wave power with equal success. As this is written, Moyes is about to market a power pack of the pulsed-power variety known as the "Speedmaster" and it's likely to make a big

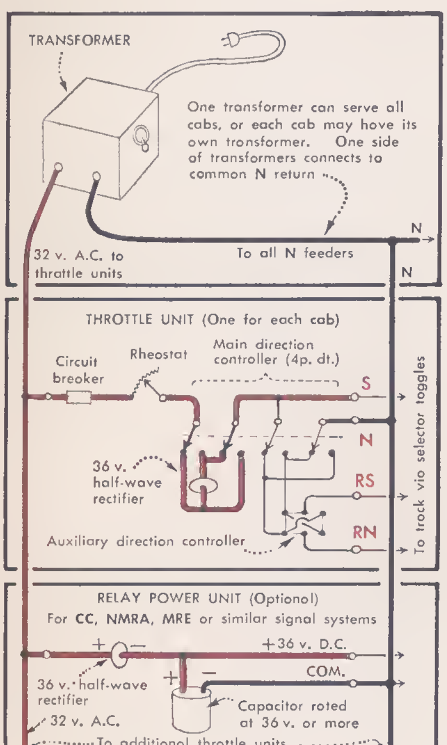


17 - 8 Even though two electrical circuits are often linked through the common-rail return feeder system, the fact that this common network is connected to every N rail prevents 24 v. from ever reaching the motor and lamps in the trains. In rare instances 24 v. can make trouble if you run a train across gaps into a block that has not been properly aligned for the train's direction of travel — but that isn't good operating so shouldn't be a cause for complaint about the wiring.

change in our engine operating habits. While a special pack is required to get the full speed range with pulsed power, you can use pulsed power for switching with an ordinary pack by making the simple change shown in Fig. 17-9.



17 - 9 You can use ordinary power packs to run trains at slow and medium speeds by cutting a connection and adding a toggle. After seeing the effect of pulsed-power on your locomotives, you may be tempted to get a regular pulsed-power type of power plant.



17 - 10 Here is a pulsed-power wiring scheme similar to the one used in the "Speedmaster" line of control equipment. One transformer can power several throttle units but still you can have common-rail wiring advantages at the same time. Each throttle unit has its own rectifier. The relay power unit at the bottom is optional. It makes it easier to have operating signals on your pike without resorting to contacts or other awkward methods of operation. For capacitor size allow 100 mfd. per relay.

A unit power and control system of some merit is illustrated in Fig. 17-10. It not only supplies pulsed power from only one transformer, but also can supply 24 v. or more for signaling circuits. Even common-rail power return wiring can be used. (One side of the transformer is shown connected to the common system. This is unusual but correct for the particular wiring scheme shown).

Operation of locomotives with pulsed power is a little more noisy than with ordinary power, but this noise is in itself one of the things that makes engines perform better — a mild vibration of the armature of the motor.

Accessories

Power packs come with a lot of handy features such as an on-off switch, pilot light and terminals arranged in a place where you can make your connections conveniently. There are also features which are necessary to train operation and if they are not included in your pack, you are going to have to provide for them. These include the throttle, usually a rheostat, a direction-control toggle for reversing the train and, if you have a return loop, wye or turntable, you will need an extra direction-control toggle as well. If your pack does not include this last feature the diagram shows how you can add it yourself.

Voltmeters and ammeters are very useful and when bought with the power packs they may cost less than when bought separately. Sometimes you'll find a power pack comes with a fuse instead of a circuit breaker. By all means replace this fuse with one of the little circuit breakers sold in hobby shops. It will slip right into the fuse clip. A fuse is good for only one power failure but the circuit breaker is used over and over again. One of the power packs recently put on the market has a circuit breaker which is self-resetting. It keeps pumping on and off until you find the trouble.

Very few throttle-type packs seem to be designed for real convenience to the engineer running a train. Some packs have connecting terminals in a place that looks O. K. in the store but when installed turns out to be on top or in front instead of at the side. Some of the nice features found on the newer packs include lever-type throttle handles. One maker has plug-in controller units so that you can add any number of rheostats just by plugging them into a large power unit. Another manufacturer has substituted a special kind of rectifier for the usual selenium rectifier in order to get better regulation. This same pack uses a potentiometer instead of a rheostat for speed control, giving good regulation and particularly good control of trains at low speeds.

There are several small packs particularly designed for use with multiple power supply. One comes without controls, another with a simple speed control which is merely a sliding connection riding over the coil of the transformer. Others provide a regular rheostat. The rheostat seems to give the best speed control but costs more. Generally speaking, you get about what you pay for in power packs and most packs will last a long time.

Maintenance of power packs

Here's about all you have to do to keep a power pack in good condition:

1. Keep it in a drafty location or at least where air can circulate freely around the pack to keep it cool.

2. See that the fuse or circuit breaker is rated for no more or little more than the maximum value of amperes the pack is supposed to deliver.

3. Use the pack at least once a month. This keeps it from deteriorating chemically and helps dry out moisture.

4. Clean all the dust from the parts about once a year. Sometimes you can blow the dust out through the ventilating openings. At other times you have to open the case and use a soft brush. If there are no ventilating holes, the pack won't need inside cleaning.

Technical requirements

Finally, I'd like to point out that the most important things in buying a pack are:

1. The pack should be able to deliver its full rated load of amperes for at least six hours without overheating.

2. The voltage across the terminals of the pack, while delivering its full rate of current, should not be lower than 12 v. It doesn't matter if it's higher.

3. If the pack is to operate several trains at the same time, the regulation should be good. The simplest test for this is to run two trains with the pack and see how much one train's stops and starts affect the operation of the other. Regulation is not important if you use multiple power supply.

Block Wiring

THE secret of planning your track wiring to handle several trains is not in electrical knowhow, but in figuring out where the trains will go. This isn't easy to do in your head, but if you draw a plan of your track and drag limp pieces of string (to represent engines and trains) around the lines, you'll learn a lot of things about operation planning.

This string-on-paper idea is a lot more fun to do if you get another model railroader to help. With four hands you can handle the "trains" more easily and it will be like playing a game.

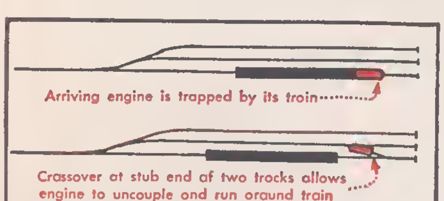
While you study your future operations, consider all these possible train movements:

1. Train arrives in yard, road engine is sent to the enginehouse, caboose to the crummy track.
2. Switcher sorts cars and arranges them into new trains.
3. Road engine couples on for another run, and leaves for the main line.

Be sure these operations are ones you can really do. For instance, if your arrival track hasn't a switch at the far end, your locomotive will be trapped beyond the train, Fig. 18-1. Also, plan the same operations two ways, entering the yard caboose first as well as engine first.

Next, plan your mainline train movements. What you can do will depend on the kind of railroad you have and how large it is:

4. Consider the effect of other trains running past the yard while you try to make the switching moves already listed.
5. How about trains going in both directions on the main at the same time? Will they make "meets" in passing sidings and along stretches of double track?
6. How about a fast train overtaking a slow one?
7. Will you operate a local freight that will do a lot of switching along the main line?
8. Are there any crossings, junctions, or other bottlenecks where trains will have to wait their turns to pass over the same piece of track?
9. Are there to be any places where helper engines will be cut off?



18-1 Every yard needs a runaround track.

When you get the actual operation possibilities of your railroad in mind, you're ready to plan your "blocks."

A block, for our purposes, is a place where you can stop or slow one train without affecting any of the other trains in other blocks. It's a sort of electrical island and your railroad will consist of a half dozen or more, perhaps as many as 30 of these islands, each with a separate electric control wire running to your control panel.

Depending on how you build your control panel, you can run trains into different blocks at different speeds. There should be an on-off switch for each block, but a block need not have its own rheostat. That would be very expensive and not the best control scheme anyway. Usually, a block will either share a rheostat with several other blocks or else cab control will be installed. You can divide your railroad into blocks in many ways, and if you get too many blocks no harm is done except that your control panel will cost a bit more for toggles or other control devices. The basic rule is to:

Provide enough blocks so that each train is always in a different block from all other trains.

Fortunately, this is an ideal that is easy to realize.

Let's go through all those train operations again, but this time let's pencil some block boundaries across the tracks. We need enough such boundaries so that at least one boundary separates each train from every other train at *all* times.

For example, consider a train waiting on the side track for another to pass, like this:

I've drawn the two block boundaries in color so the train will not be in the same block with another train, no matter from which direction the other comes.

After the No. 2 train has passed, the first train wants to get out on the main again so we need a third boundary, like this:

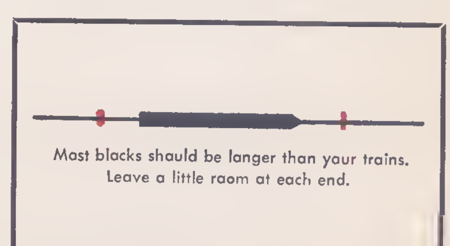
This insures that the two trains, now both on the main line, are separated by at least one boundary. These three boundaries are a minimum requirement at any passing siding. But even this is not ideal. If train No. 2 should happen to arrive first, you'd need another boundary at the right to keep the train separated from the approaching No. 1. So four boundaries are best:

You can analyze every part of your track in this way, and you'll end up with from half a dozen up to twenty or more such boundaries depending on your track plan.

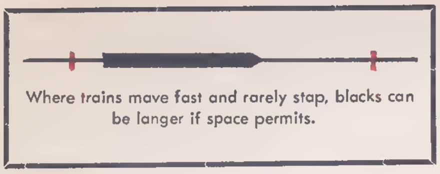
When you're through, the lengths of track extending between one boundary and the next are your "blocks" or more properly "control blocks."

This process would be tedious if you had to figure everything out, but you don't. Here are some simple rules that apply to common track patterns, and they'll account for most of your blocks if not all of them.

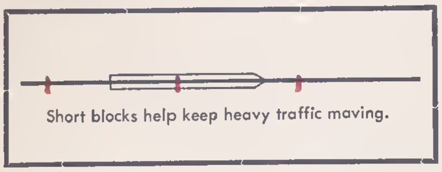
1. Try to keep the blocks longer than your trains, Fig. 18-2.
2. If there is room, blocks should be considerably longer than your trains in any territory where the



18-2 Train-length blocks save wiring.



18 · 3 Longer blocks for speed territory.



18 · 4 Half-size blocks for dense traffic.

trains will move fast, Fig. 18-3.

3. But where traffic is heavy, you many want to allow only about half a train length per block. This makes shorter blocks that permit trains to follow one another more closely, Fig. 18-4.
4. Along any given route, whether oval or point-to-point, allow

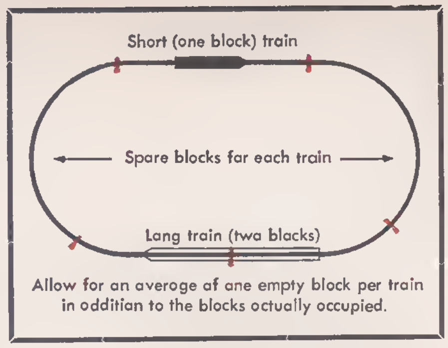
Track Plan Dimensions

	TT	HO	S	O
Scale of drawing	1″	¾″	½″	⅜″
Size of squares	18″	24″	36″	48″
Width overall	3′-11″	5′-2″	7′-9″	10′-4″
Length overall	7′-4″	9′-9″	14′-8″	19′-6″
Minimum radius	13½″	18″	27″	36″
Outer curve's radius	15⅜″	20½″	30¾″	41″

All turnouts are No. 4

Elevations are indicated in rectangles. Multiply them by ¾″ for TT, 1″ for HO, 1½″ for S, or 2″ for O gauge.

Dashes and arrowheads show foot and top of each grade. Arrow points uphill.

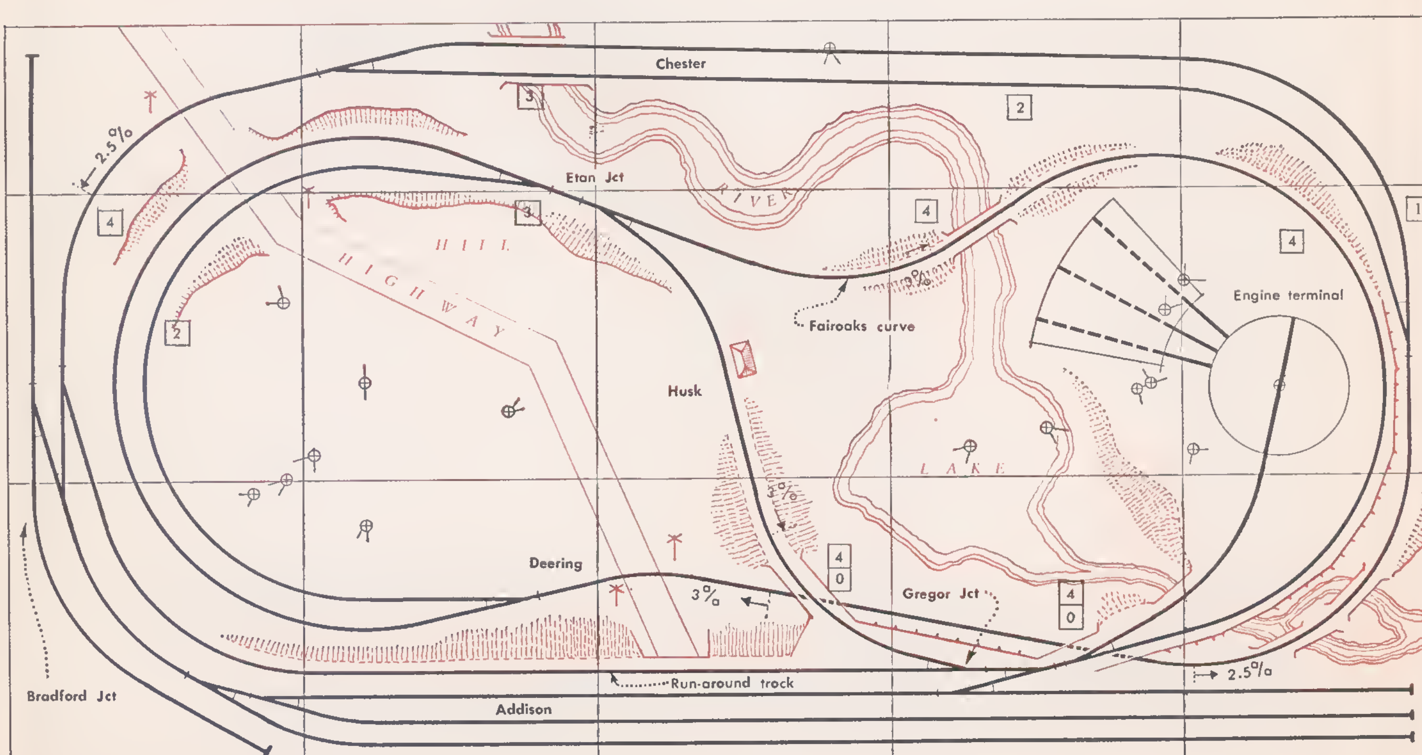


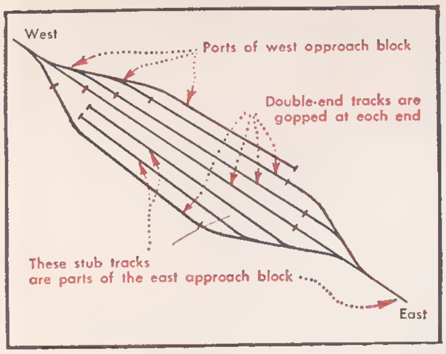
18 · 5 Spare blocks keep traffic moving.

enough blocks so that there can be an empty block per train in addition to those blocks the trains actually occupy, Fig. 18-5.

5. If a switcher must sometimes use part of the main line near a siding or at the end of a yard, consider a short block in the main line near the yard. This allows the switcher to use that part of the main line and still permits any mainline trains to approach closer to the yard before waiting for the switching maneuvers to be completed. Without such a short block the mainline train might have to wait at quite some distance from the yard. See block B6-2 near the yard on Fig. 18-8.
6. Places where trains will pass over the same point in quick succession, though over different routes, such as at crossings and junctions, should be isolated into small "interchange" blocks. This is so one train can get into the zone as soon as another has cleared it; see block B6-1, Fig. 18-8.
7. Be sure to put a block boundary in the middle of any crossover between double track whenever trains might move on both tracks at the same time.
8. Consider the use of short blocks at the bottom and top of grades so that the control of the helper and the regular road engine can be separate when the helper is coupling on or uncoupling from the train. In this case the block boundary should be located approximately under the coupler of the helper engine.
9. Yard tracks with a ladder turnout at each end should be treated with two boundaries, the same as we did with the passing siding. Single-ended yard tracks can remain part of the approach track block, Fig. 18-7.
10. If in doubt, having too many blocks will do little harm, but may

18 · 6 This is the track plan used in many of the wiring examples through the last three chapters of this book. It is a good operating plan for such a compact space since it provides for round and round as well as terminal-to-loop operation. Of course a number of industrial spurs may be added to facilitate roadside switching, but such spurs do not affect block wiring. There are three passing sidings in the twice-around oval, a good operating combination because trains running in opposite directions need not always meet at the same sidings.





18 - 7 Only double-ended yard tracks are blocks.

add to the cost of the toggles on your control panel.

A practical example

The railroad in Fig. 18-6 takes only a modest space considering its track pattern, and it's a good one on which to practice block planning. Fig. 18-8 shows the boundaries I'd recommend for most model railroad operations.

I've assigned each block a number, too. This helps keep your wiring untangled. On a small railroad you can number blocks any way you want. On a bigger railroad, it pays to be more systematic. The planners of real railroads number their signal blocks according to the distance from some arbitrary zero point, perhaps the largest terminal on the line.

They often assign even numbers to any predominantly eastbound tracks and odd numbers to westbound tracks. Thus on a particular railroad a block 24 miles from base and on track 1 might be numbered 241. A block on the next track opposite (or the eastbound main if it's a double track) would be 242.

Another railroad company might use the same idea in a different way, having a number like this: 24-1; or still another railroad might use 024.1 or even inverted as 1024.

These prototype block numbering systems are often confusing when you try to use them on a small track plan. You get too many similar numbers such as 21, 22, 12, etc. But if you use the letters A, B, C, D, etc. for parallel tracks, and a number for the distance from the starting point, the confusion is reduced. That's how I numbered the blocks on the Fig. 18-8 plan.

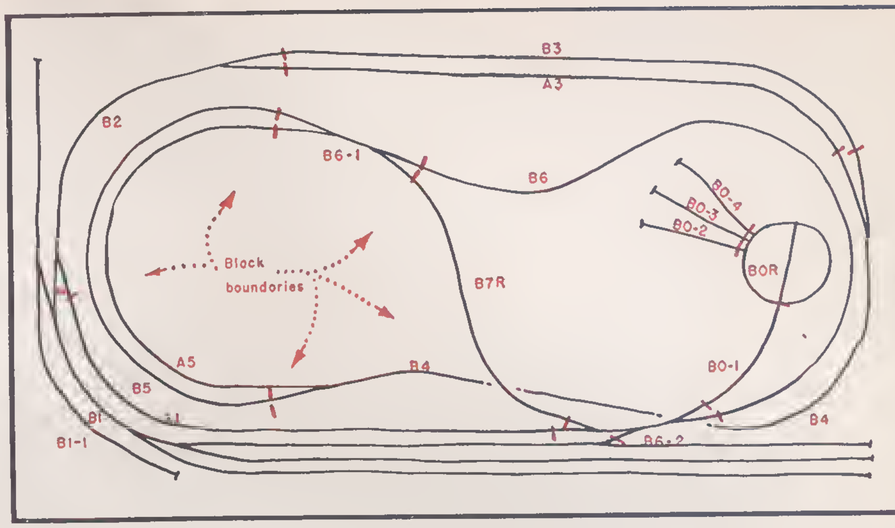
B is for Blocks along the main track.

A is for Blocks on the alternate track.

C, D, E, etc. are for additional tracks if there are any.

Interchange and other blocks too short to hold a train are given a sub-block number. Sub-blocks B6-1 and B6-2 share the 6 of block B6.

Engine terminal blocks can be given the number 0 so they don't interfere with the distance numbers.



18 - 8 You can plan your blocks on a crude drawing of your own track plan.

Naming stations in alphabetic order is helpful to your guests while learning to operate your railroad.

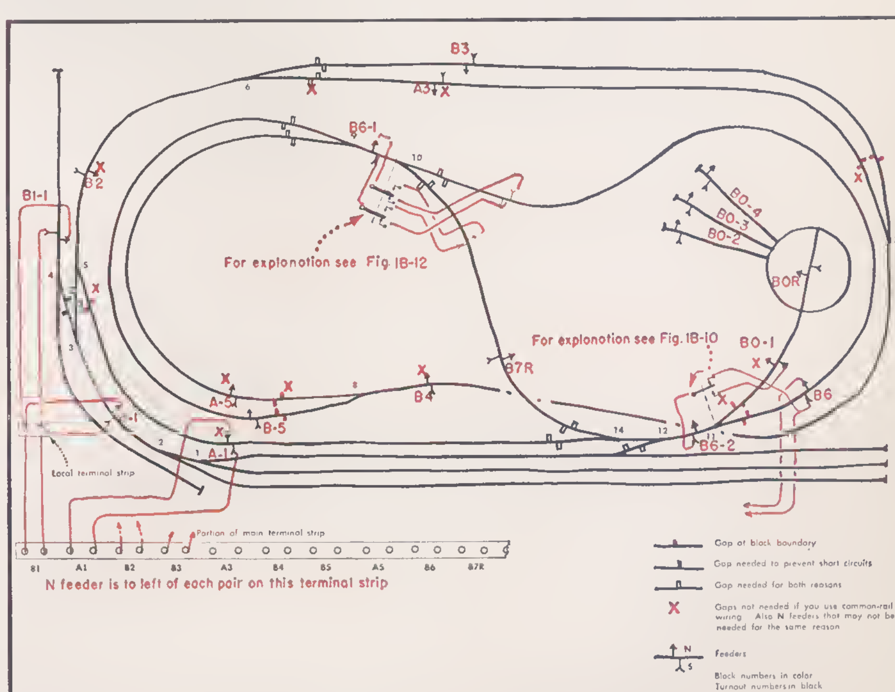
Let's see how trains would use some of these blocks. Notice how block B1 includes all of three yard tracks and a switchback spur as well. Why isn't some of this divided into separate blocks?

Well, I figure that even though you do one kind of switching in the yard and a different kind of switching in the zig-zag spur, you can't do both at the same time. At least it's very unlikely. So, since two trains will not operate at the same time in all this territory, you need only one block.

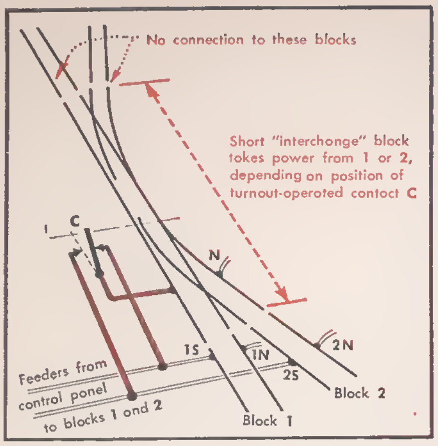
Block A1 must be separate from block B1 because mainline trains may want to run by on A1 while the yard is used for switching moves. These two blocks can also be used as a main line and passing track and also as a run-around track to move engines to the other end of their trains.

In a pinch, blocks B6, B6-2 and B0-1 could all be combined into one. But with three separate blocks more train movements are possible. For instance, while an engine is backing from the yard through B6-2 to reach the turntable, a mainline train can approach into block B6 to get closer to the yard before stopping.

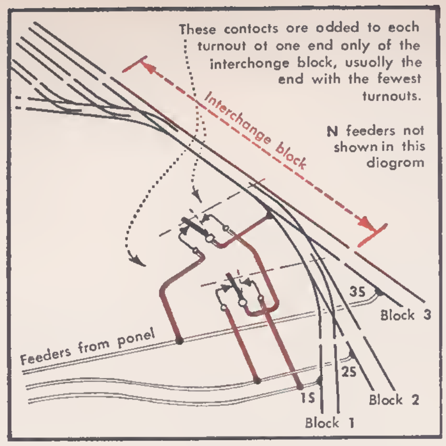
Likewise, after the engine has cleared block B6-2, the train can move into the yard while the lone engine can still get onto the turntable after the table has come around.



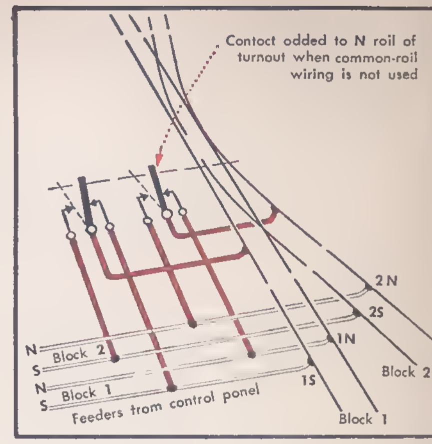
18 - 9 Gaps are added at all block boundaries. A sample terminal connection is also shown.



18 - 10 This little-known trick saves much wiring. Instead of providing a toggle for "interchange" blocks on your panel, let the short block tap its power from nearby longer blocks. Contacts on the connecting turnout do the trick.



18 - 11 This is the same except that there are more than two approach tracks at each end of the interchange block. Put contacts on the connecting turnouts at the end with the fewest approaches as that takes less equipment.



18 - 12 If you do not use common-rail wiring, you'll have to double the number of contacts in the previous two examples and wire the N rails together in the same manner as the S feeders are handled.

Blocking the main line

In general, any route, whether it is point-to-point or oval, consists of either double or single track with passing sidings. In the case of double track, the length of blocks should be determined by the speed of the train and the density of the traffic, as already mentioned, and if the plan includes ovals there ought to be at least four blocks in each oval. In this way two trains can follow each other around the same oval.

Where the line is single track with passing sidings, you can usually figure three blocks per siding. One block is the main line at the siding while another is the passing track. For example, see blocks B3 and A3 in Fig. 18-8. The third is the single track connecting to the next siding in either direction down the line. This third block includes the siding turnouts at each end of the single track, as in block B2 of Fig. 18-8.

Only if traffic is very heavy would there be any need to divide either the siding or single track between siding blocks into a greater number.

On our plan, B6-1 and B6-2 are exceptions to these generalities. We've already talked about B6-2. In the case of B6-1, there are four possible routes. You can run from either the main or the return cutoff through B6-1 into either the main or the passing track, blocks B5 and A5. It's conceivable that two trains might want to use block B6-1 in quick succession. By keeping this block very short, and separating it from block B6, the rear end of each train will clear the track sooner to let another train enter.

Gaps and feeders

After you've marked your block boundaries, you're ready for actual track wiring, Fig. 18-9. Install a terminal strip where all your track feeders can be connected. Put it near the spot where your control panel will be placed. Be sure there are enough terminals so each of the blocks has two, one for the *S* rail, another for the *N* rail. On our sample plan there are 15 blocks so at least 30 terminals should be available. You may need more for switch machines, lamps and power supply.

Now apply the usual rules for locating gaps and feeders to your track, from page 43.

The rules apply in every way to this block wiring, but there are two new things to consider. First, be sure there is a gap in one or both rails near each place where you've marked a block boundary. Sometimes the rules already called for this and so much the better. Secondly, examine to see if it is necessary to add new feeders to either one side or the other of any new gaps in order to get power to the new blocks you've created. This is because the new gaps may have isolated some rails from their original feeders.

I said you needed a gap in one or both rails near each place where you've marked a block boundary. You need a gap in both rails at a block boundary if the same power pack is going to handle more than one train. However, if you plan to run each train from a separate pack (multiple power supply or twin power supply), or if you're going to use the pulsed-power scheme of Fig. 17-10 you can sometimes omit the gap in the *N* rail. Rule X shows when you can omit an *N* rail gap, but if in doubt, put in both gaps.

Finally, connect *all* the *S* and *N* feeders in each block to the terminals assigned to the *S* and *N* feeders of that particular block. Most blocks will have only one pair of feeders, but some, like block B1 in our example, will have more.

Interchange blocks

Short blocks at junctions and crossings (like blocks B6-1 and B6-2 in the sample plan) are kept short for only one reason: so they may be quickly made available to one train after another has moved away. There is no need to put a toggle switch on your control panel (or panels) to turn power on or off in such a short block as you cannot even hold an entire train in that small a place. Instead, it is usually cheaper if the power for interchange blocks is borrowed from one or the other of the approach blocks, as in Fig. 18-10.

Notice how a spring contact is added to the tie rod of the turnout at one end of the short block. No matter which way you throw the turnout, the short block becomes an electrical part of the adjoining long block. This contact that works automatically makes it unnecessary to provide a toggle for the short block on the control panels, and eliminates a hand motion while you run a train through the junction.

If an interchange has only two entrances at each end, it doesn't matter whether you add the contact to the east turnout or the west turnout. But when one end has more entrances than the other, put the contacts on the turnouts at the end with the fewest entrances, Fig. 18-11.

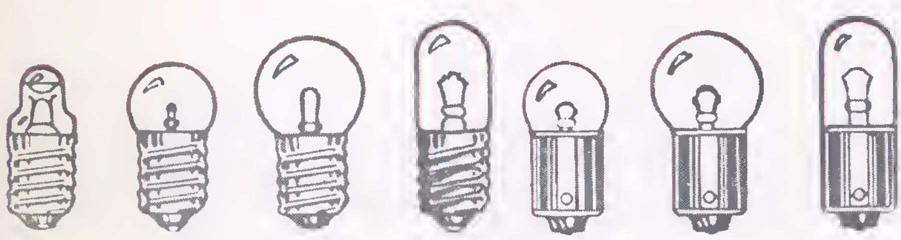
The contacts are shown operated by the throw rod, but they could be mounted on the switch machine or even be a part of the switch machine's toggle on your control panel.

These diagrams assume you will use one of the common rail systems so you do not need contacts on the *N* rail side. But if your railroad is powered with only one power supply, or if one of the blocks involved is a turning track as B7 is on our plan, repeat the wiring on the *N* side, adding a duplicate set of contacts as in Fig. 18-12.

Lamps Suitable for Model Railroad Use

Lamp Number	Bulb Size	Base	Rated Volts	Design Volts	Current Amps	Bead Color	12 v. Dropping Resistor Ohms	Watts
123	G-3½	Min. Sc.	1.2		0.3		35	5
112*	TL-3	Min. Sc.	1.1	1.2	0.22	Pink	50	5
48	T-3¼	Min. Sc.	2.0		0.06	Pink	180	2
49	T-3¼	Min. Bay.	2.0		0.06	Pink	180	2
Surgical	3/16"x½"	None	2.0	3.8	0.35		30	5
233	G-3½	Min. Sc.	2.3		0.27		50	5
49A	T-3¼	Min. Bay.	2.1		0.12	White	100	5
222*	TL-3	Min. Sc.	2.2		0.25	White	50	5
41	T-3¼	Min. Sc.	2.5		0.5	White	22	10
43	T-3¼	Min. Bay.	2.5		0.5	White	22	10
292	T-3¼	Min. Sc.	2.9		0.17	White	68	2
292A	T-3¼	Min. Bay.	2.9		0.17	White	68	2
Grain-o'-Wheat†	5/32"x5/16"	None	6		0.1		60	1
40	T-3¼	Min. Sc.	6-8		0.15	Brown	47	2
40A	T-3¼	Min. Bay.	6-8	6.3	0.15	Brown	47	2
47	T-3¼	Min. Bay.	6-8	6.3	0.15	Brown	47	2
50	T-3½	Min. Sc.	6-8		0.20	White	33	2
44	T-3¼	Min. Bay.	6-8	6.3	0.25	Blue	33	2
46‡	T-3¼	Min. Sc.	6-8		0.25	Blue	33	2
51‡	T-3½	Min. Bay.	6	7.5	0.25		33	2
55	G-4½	Min. Bay.	6	7.0	0.45		15	5
605	G-4½	Min. Sc.	6	6.15	0.50	Brown	15	5
1446	G-3½	Min. Sc.	12		0.20			
57	G-4½	Min. Bay.	12	14.0	0.22			
428	G-4½	Min. Sc.	12		0.25			
1481	T-3¼	Min. Bay.	14		0.15			
1447	G-3½	Min. Sc.	18		0.15			
432	G-4½	Min. Sc.	18		0.25			
1455	G-5	Min. Sc.	18		0.25	Brown		
1455A	G-5	Min. Bay.	18		0.25	Brown		

* Lens bulb.
† For other grain-o'-wheat bulbs ask dealer about voltage and current rating.
‡ Frosted bulb.



TL-3 G-3½ G-4½ T-3¼ G-3½ G-4½ T-3¼

Miniature Screw Base Miniature Bayonet Base

While there are many sizes of lamps suitable for model railroad use, it should not be difficult to choose one or two for your needs. Most important is availability. Sizes sold for radio dial uses are probably the most commonly stocked. These include most of the 40 and 50 series lamps listed in our chart. A convenient way to buy them is in boxes of 10 bulbs.

Automobile bulbs are also easy to obtain but draw too much current for most model illumination needs. Also the bulbs are rather large.

In general the brightness of a bulb is proportional to the rated voltage multiplied by the current. If you run a bulb at 10 or 20 per cent less than its rated voltage it will last much longer. This is a consideration when bulb replacement might be a nuisance. A bulb running at reduced voltage will not be as bright and its color will be more toward orange.

Bulb sizing is in units of ⅛". The letter G represents a globe shape, T, tubular, and TL, tubular with a lens molded into the front.

A number of extra-small bulbs, such as the grain-o'-wheat and surgical types, are now appearing on the model railroad market. Two of them are listed in the table. These have been on the market a long time; similar bulbs of other voltages are also offered but are not yet sufficiently standardized to be listed in this table.

In the last two columns of the table I have shown the size of fixed resistor you can use in series with a bulb to operate it from a 12 v. power supply. These resistors can be purchased from a radio-parts supply house for about 20 cents each. They not only protect the bulb from operating on too high a voltage but also tend to lengthen its life, as the strain on a bulb when it is first turned on is not as great.

Resistors in 5 w. values are not stocked by many dealers but you can use two 2 w. resistors instead. If the two are connected in parallel, each resistor should have double the resistance called for in the table.

Another way you can use lamps on a higher voltage than they are rated for is to put two in series. For instance, two 6 v. bulbs can be connected in series to operate from 12 v. provided their current ratings are the same. You can even combine lamps of different voltage ratings as long as the current rating is the same. Lamps of 12 v. to 18 v. ratings generally will not last as long as lamps designed for lower voltages, provided each is operated at its rated voltage. The lamps in the higher voltages also require more wattage and produce more heat, so in general a 6 v. bulb or sometimes one of even lower voltage than this is a good choice where it can be used.

Both screw-in and bayonet-type miniature bases are made. Bulbs can be used without sockets if you solder the connecting wires directly to the base and contact tip. Some of the smallest bulbs come with two pigtails which are soldered into the circuit.

If you use lamps with minimum current ratings you will be able to power more lamps from the same source. Use larger current ratings only if you need more light. The most economical bulb of all listed in this respect is No. 48 in the miniature screw base or No. 49 which is the same in the miniature bayonet base. Three of these may be used in series from a 6 v. transformer.

It does not matter whether lamps operate from A.C. or D.C. When you operate bulbs from the same power pack that runs trains, however, you're running a risk of burning out the bulbs because the no-load output voltage of the 12 v. power pack may rise to as much as 16 v. or 24 v.